

SDMS US EPA REGION V -1

**SOME IMAGES WITHIN THIS
DOCUMENT MAY BE ILLEGIBLE
DUE TO BAD SOURCE
DOCUMENTS.**

Appendix
A-B

**REMEDIAL INVESTIGATION REPORT
LENZ OIL SERVICE, INC. SITE
LEMONT, ILLINOIS**

VOLUME II OF II

REVISION: 1

SUBMITTED BY:

LENZ OIL SETTLING RESPONDENTS

OCTOBER 16, 1992

PREPARED BY:

**ENVIRONMENTAL RESOURCES MANAGEMENT-NORTH CENTRAL, INC.
102 WILMOT ROAD, SUITE 300
DEERFIELD, ILLINOIS 60015
PROJECT NO. 0252**

**BASELINE RISK ASSESSMENT
FOR THE
LENZ OIL SERVICE, INC., SITE
LEMONT, ILLINOIS**

FINAL REPORT

Prepared for

**U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Waste Programs Enforcement
Washington, DC 20460**

Work Assignment No.	:	C05112
EPA Region	:	5
Date Prepared	:	August 24, 1992
Contract No.	:	68-W9-0006
PRC No.	:	009-C050112
Prepared By	:	PRC Environmental Management, Inc.
Contractor Project Manager	:	Eric Morton/Scott Lloyd
Telephone No.	:	(312) 856-8700/(708) 255-4166
EPA Work Assignment Manager	:	Nan Gowda
Telephone No.	:	(312) 353-9236

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1
1.1 OVERVIEW	1
1.2 SITE BACKGROUND	1
1.3 SCOPE OF RISK ASSESSMENT	8
2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN	10
2.1 HISTORICAL DATA	10
2.2 BACKGROUND SAMPLING	11
2.3 SAMPLE APPROACH AND DATA QUALITY OBJECTIVES	11
2.3.1 Groundwater Sampling	14
2.3.2 Soil and Sediment Sampling	14
2.3.3 Surface Water Sampling	15
2.3.4 Validation of Sample Data	18
2.4 DATA EVALUATION	18
2.4.1 Data Collection	18
2.4.2 Data Evaluation in Selecting Chemicals of Potential Concern	19
2.4.2.1 Frequency of Detection	19
2.4.2.2 Comparison with Background Levels	19
2.4.2.3 Data Qualifiers	20
2.4.2.4 Availability of Carcinogenic Slope Factors (CSF) or Reference Dose Values	21
2.4.2.5 Tentatively Identified Compounds (TICs)	21
2.4.2.6 Uncertainty	21
2.4.3 Chemicals of Potential Concern in Environmental Media	22
2.5 SUMMARY OF CHEMICALS OF POTENTIAL CONCERN	23
3.0 EXPOSURE ASSESSMENT	26
3.1 PHYSICAL SETTING	26
3.1.1 Physiography	26
3.1.2 Surface Water Hydrology	26
3.1.3 Geology	27
3.1.4 Climate	27
3.2 POTENTIALLY EXPOSED POPULATIONS	28
3.2.1 On-site Trespassers	29
3.2.2 Off-site Populations	29
3.2.3 Future On-site Construction Workers	30
3.2.4 Future On-site Residents	30
3.2.5 Surface Water Users	30
3.2.6 Recreational Surface Water Users	30

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
3.2.7 Fish Consumers	31
3.2.8 Groundwater Users	31
3.2.9 Subpopulations of Potential Concern	31
3.3 IDENTIFICATION OF EXPOSURE PATHWAYS AND EXPOSURE POINT CONCENTRATIONS	33
3.3.1 Soil Exposure Pathways	33
3.3.2 Air Exposure Pathways	34
3.3.3 Groundwater Exposure Pathways	34
3.3.4 Surface Water Users Exposure Pathways	35
3.3.5 Recreation Surface Water Users Exposure Pathways	36
3.3.6 Fish Consumption Exposure Pathway	37
3.3.7 Summary of Exposure Pathways to be Quantified in This Assessment	37
3.4 QUANTIFICATION OF CHEMICAL INTAKES	38
3.4.1 Standard Exposure Parameter Assumptions	39
3.4.2 Exposure Estimation Methods	40
3.4.3 Exposure Scenarios	41
3.5 UNCERTAINTIES IN EXPOSURE ASSESSMENT	55
3.5.1 Exposure Pathway Identification	56
3.5.2 Exposure Parameters and Assumptions	56
3.5.3 Assumption of Steady-State Conditions	62
3.5.4 Environmental Chemical Characterization.	62
3.5.4.1 Seasonal Variations	62
3.5.4.2 Nonrandom Sample Collection	63
3.5.4.3 Assumption of Uniform Concentrations	63
3.5.4.4 Treatment of Nondetection Results	63
3.5.4.5 Comparison to Background Concentrations	64
3.5.4.6 Unfiltered Versus Filtered Results	64
3.5.5 Modeling Procedures	64
3.6 SUMMARY OF EXPOSURE ASSESSMENT	64
4.0 TOXICITY ASSESSMENT	66
4.1 DOSE RESPONSE INFORMATION	66
4.1.1 TOXICITY INFORMATION FOR NONCARCINOGENIC EFFECTS	66
4.1.2 TOXICITY INFORMATION FOR CARCINOGENIC EFFECTS	67
4.1.3 CHEMICALS WITH NO EPA TOXICITY VALUES	68
4.2 ASSUMPTIONS AND UNCERTAINTIES REGARDING TOXICITY VALUES	68
4.3 TOXICITY SUMMARIES	74

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
5.0 RISK CHARACTERIZATION	80
5.1 RISK CHARACTERIZATION METHODOLOGY	80
5.1.1 Carcinogenic Risks	80
5.1.2 Noncarcinogenic Risks	82
5.2 CURRENT LAND USE CONDITIONS	84
5.2.1 Recreational Uses	84
5.2.2 Trespassers	85
5.2.3 Current Residents	87
5.3 FUTURE LAND USE CONDITIONS	87
5.3.1 Short-term Workers	87
5.3.2 Future Residents	90
5.4 COMBINED PATHWAY CANCER RISKS AND HAZARD INDICES	94
5.4.1 Recreational Pathways	94
5.4.2 Trespasser Pathway	94
5.4.3 Current Adjacent Resident Pathway	94
5.4.4 Future On-Site Residential Pathways	100
5.4.5 Future Off-Site Residential Pathways	100
5.4.6 Future Short-term Worker Pathway	100
5.5 QUALITATIVE RISK ASSESSMENT	100
5.5.1 Chemicals Without Toxicity Values	100
5.5.2 Exposure to Lead	101
5.6 UNCERTAINTIES IN RISK CHARACTERIZATION	101
5.6.1 Risk Factors	102
5.6.1.2 Adjustment of Risk Factors	104
5.6.1.3 Slope Factors	105
5.6.1.4 Lack of Risk Factors	105
5.6.2 Risk Summations	105
5.6.3 Exposure Periods	105
5.6.4 Central Tendencies	106
6.0 ECOLOGICAL RISK ASSESSMENT	111
6.1 INTRODUCTION	111
6.1.1 Objective of the Assessment	111
6.1.2 Scope of the Investigation	111
6.1.3 Site Characterization	112

TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
6.2	ECOLOGICAL RECEPTORS	112
6.2.1	Potentially Affected Species	112
6.2.2	Potentially Affected Habitats	113
6.2.3	Contaminants of Ecological Concern	114
6.2.4	Exposure Pathways	116
6.3	EXPOSURE ASSESSMENT	118
6.3.1	Quantification of Release, Fate, and Transport	118
6.3.2	Exposure Point Concentrations	118
6.3.3	Characterization of Receptors	118
6.4	ECOLOGICAL EFFECTS ASSESSMENT	119
6.4.1	Aquatic Toxicity Data	119
6.4.2	Terrestrial Toxicity Data	120
6.5	RISK CHARACTERIZATION	120
6.5.1	Adverse Effects	120
6.5.2	Uncertainty	121
7.0	RISK ASSESSMENT SUMMARY	123
7.1	CHEMICALS OF POTENTIAL CONCERN	123
7.2	EXPOSURE ASSESSMENT	124
7.3	TOXICITY ASSESSMENT	125
7.4	RISK CHARACTERIZATION	125
7.5	ECOLOGICAL CHARACTERIZATION	126
8.0	REFERENCES	127

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1-1 LENZ OIL SERVICE, INC. WASTE STREAMS	5
2-1 CHEMICALS OF POTENTIAL CONCERN (CPC), LENZ OIL SERVICE SITE	24
3-1 LENZ OIL SITE WELLS POTENTIALLY IMPACTED BY SITE CONTAMINANTS	32
3-2 AREAS OF EXPOSURE ASSESSMENT UNCERTAINTY AND EFFECTS ON EXPOSURE ESTIMATES	57
3-3 RME AND AVERAGE EXPOSURE FACTORS AND SUMMARY INTAKE FACTORS FOR RESIDENTIAL PATHWAYS	59
3-4 RATIO OF CENTRAL TENDENCY INTAKE FACTORS TO RME INTAKE FACTORS, RESIDENTIAL PATHWAYS	61
4-1 ORAL REFERENCE DOSES FOR CONTAMINANTS OF CONCERN	69
4-2 INHALATION REFERENCE DOSES FOR CONTAMINANTS OF CONCERN	71
4-3 ORAL SLOPE FACTORS FOR CONTAMINANTS OF CONCERN	72
4-4 INHALATION SLOPE FACTORS FOR CONTAMINANTS OF CONCERN	73
5-1 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES Current Land Use Conditions - Recreational	86
5-2 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES Current Land Use Conditions - Trespasses	88
5-3 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES Current Land Use Conditions - Residential	89
5-4 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES Future Land Use Conditions - Short-term Worker	91
5-5 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES Future Land Use Conditions - Residential	95
5-6 SUMMARIES OF EXCESS CANCER RISKS	98
5-7 SUMMARIES OF HAZARD INDICES	99
5-8 AREAS OF UNCERTAINTY AND EFFECTS ON RISK ESTIMATES	103
5-9 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES (Central Tendency) Current Land Use Conditions - Residential	107
5-10 SUMMARIES OF EXCESS CANCER RISKS AND HAZARD INDICES (Central Tendency) Future Land Use Conditions - Residential	108

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1-1	LOCATION MAP	2
1-2	LAND USE MAP	3
1-3	PRE-REMEDIATION SITE FEATURES	6
1-4	POST-REMEDIATION SITE FEATURES	7
1-5	CONCEPTUAL SITE MODEL	9
2-1	MONITORING WELL LOCATION MAP	12
2-2	PHASES 1 AND 2 SOIL SAMPLING LOCATIONS	13
2-3	OFF-SITE SOIL AND SEDIMENT SAMPLING LOCATIONS	16
2-4	SURFACE WATER SAMPLING LOCATIONS	17

EXECUTIVE SUMMARY

PRC Environmental Management, Inc. (PRC), has prepared this baseline risk assessment report for the U.S. Environmental Protection Agency (EPA) Region 5 under Work Assignment No. C05112 under EPA Contract No. 68-W9-0006 (TES 9). The report assesses the potential human health and environmental impacts associated with the Lenz Oil Service (Lenz Oil) site located in Lemont, Illinois. The report is prepared in accordance with EPA standard guidance for performing baseline risk assessments and other guidance documents where appropriate.

BACKGROUND

The Lenz Oil site operated from approximately 1961 to 1985. The site initially operated as a waste oil collection, storage, and transport facility. Sometime prior to 1980 the facility expanded its operation to include waste solvents. Spent solvents were collected from local commercial and industrial facilities and stored at the facility before being shipped to a local recycling facility.

Site operations included material storage in above- and below-ground storage tanks, tanker trucks, drums, and surface impoundments. After numerous violations of an Illinois Environmental Protection Agency (IEPA) hazardous waste permit, the owners were ordered to perform cleanup actions and to close the facility. The IEPA initiated its own emergency remedial action at the site in April 1986. Tanks, tanker trucks, and other structures were removed from the site and approximately 21,000 tons of wastes, drums, and contaminated soils were incinerated on site. The site was listed on the EPA national priority list (NPL) in September 1989 based on site conditions that existed before the IEPA emergency remedial activities. A November 1989 agreement between EPA and Lenz Oil Service, Inc. participating respondents required that an RI/FS be performed.

This risk assessment is a link between the RI reports and the upcoming FS. The risk assessment is based on data collected on and around the site from 1991 to 1992 and was prepared following the most recent EPA guidance for conducting risk assessments. The objective of this risk assessment is to determine the magnitude and probability of actual and potential harm to public health and welfare posed by actual or threatened releases of hazardous substances from the site. The risk assessment will be used to guide selection and evaluation of remedial alternatives during the FS. This risk assessment addresses risks to human health based on potential current and future exposures to hazardous substances. Risks are determined from the RI data only; historical contamination and human exposures are not considered.

This risk assessment is presented in eight sections. The purpose of each section is described below:

- Section 1.0 provides a historical summary and describes the Lenz Oil site.
- Section 2.0 describes the identification of chemicals of potential concern evaluated in the risk assessment.
- Section 3.0 characterizes the exposure setting both on- and off-site, identifies exposure pathways, and calculates exposures for chemicals of potential concern via each exposure pathway.
- Section 4.0 evaluates toxicological properties of those chemicals that present the most significant risks at the site.
- Section 5.0 characterizes potential risks to humans from exposure to chemicals of potential concern via each identified exposure pathway.
- Section 6.0 characterizes potential risks to ecological receptors from exposure to chemical of potential concern in the site vicinity.
- Section 7.0 summarizes the information presented in the first six sections.
- Section 8.0 presents references.

Summaries of the major components of the risk assessment are included in the following sections.

CHEMICALS OF POTENTIAL CONCERN

Hazardous substances have been measured in five media (ground water, surface water, sediment, surface soil, and subsurface soil) on and off site. Sample data used in this risk assessment were obtained during Phase 1 and 2 sampling. The data were evaluated according to EPA procedures to identify chemicals of potential concern. No preliminary screening of contaminants based on toxicity was performed. Average and upper 95-percent confidence interval concentrations are presented in Appendix C. In total, up to 50 chemicals of potential concern per media evaluated are identified. These chemicals include volatile organic compounds, semivolatile organic compounds, pesticides, polychlorinated biphenyls (PCBs), and metals.

EXPOSURE ASSESSMENT

In Section 3, exposure to chemicals of potential concern is evaluated under two sets of land use conditions: (1) current land use conditions including residential, trespassing, and recreational and (2) future land use conditions in which the site or adjacent land is used for residential development. Exposure pathways are developed based on evaluations of the physical setting on and off site, the potential fate and transport of chemicals of potential concern, and assumed activity patterns of existing or future populations.

Exposure pathways evaluated under current land use conditions include site trespassing, recreational or exploratory activities in an adjacent drainage ditch and the Des Plaines River, and residential use of adjacent land. Exposure pathways evaluated under future land use conditions include residential use of on-site and adjacent land, and short-term worker activities on the site.

EVALUATION OF TOXICOLOGICAL PROPERTIES

Contaminants that result in significant risks at the site include:

- arochlor isomers
- carcinogenic PAHs
- pesticides (chlordane, Gamma-BHC, DDE, DDD)
- trichloroethene
- tetrachloroethene
- chloroform
- 1,1-dichloroethene
- 1,2-dichloroethene
- vinyl chloride
- benzene

RISK CHARACTERIZATION

The exposure pathways and contaminants that result in significant human health risks at the site are summarized in Section 7 of this report. The most significant cancer risks for a future residential receptor using contaminated on-site groundwater range from 4×10^{-2} to 4×10^{-8} . A hazard index of 1.7 is also predicted for this pathway. Contaminants of primary concern include:

- PCBs
- chloroform
- trichloroethene
- 1,1-dichloroethene
- 1,2-dichloroethene
- vinyl chloride.

The most significant cancer risks for a future residential receptor using contaminated off-site groundwater range from 10^{-4} to 10^{-5} , and the hazard indices range from 1.7 to 6.9×10^{-3} .

The most significant soil ingestion and dermal contact cancer risks for a future on-site receptor are in the 10^{-5} range. Contaminants of primary concern are:

- PCBs
- arochlor isomers
- carcinogenic polycyclic aromatic hydrocarbons (PAHs) including benzo(a)pyrene and equivalent compounds.

Soil cancer risks resulting from shorter exposures durations (that is, for trespassers and short-term workers) are in the 10^{-8} range.

The most significant inhalation cancer risks for current and future residential receptors on or adjacent to the site range from 10^{-2} to 10^{-3} . Contaminants of primary concern are

- carcinogenic PAHs
- trichloroethylene
- tetrachloroethene
- pesticides including aldrin, chlordane and gamma-BHC

The hazard index predicted from exposure to this pathway is less than 1. Inhalation cancer risks resulting from shorter exposure durations (for example, future on-site workers) are in the 10^{-4} range. Predictions of risks due to inhalation are based on conservative air modeling, and the use of soil boring data from 0 to 2.5, to 0 to 5 feet deep to characterize chemical concentrations in surface soil. Therefore, these risks are likely to be less significant.

For comparison, excess cancer risks and hazard indices based on less conservative (central tendency) exposure assumptions were also calculated. All central tendency risks were within slightly more than order of magnitude (up to 20 times) less than RME risks calculated for the same pathways.

ECOLOGICAL CHARACTERIZATION

Currently, there are no data available indicating that biological receptors are experiencing adverse effects from on-site contaminants. The potential for future adverse effects depends largely on the behavior of the groundwater contaminant plume as well as on the pH and hardness of the surface water in the ditch. Potential adverse effects can be expected in detritus-epibenthic prey-based food chains in the ditch, wetland, and river habitat. Burrowing mammals also face adverse effects if they come in contact with groundwater or ditch sediments. The greatest threat to ecological receptors is posed by heavy metals, and PAHs.

1.0 INTRODUCTION

1.1 OVERVIEW

The Lenz Oil baseline risk has been prepared as a part of the remedial investigation and feasibility study (RI/FS) for the Lenz Oil National Priority List (NPL) site in Lemont, Illinois. The purpose of the RI/FS is to characterize the nature and extent of risks posed by uncontrolled hazardous waste sites and to evaluate potential remedial options for the site. The RI serves as a mechanism for data collection, site and waste characterization, human health and environmental risk evaluation, and treatability testing (EPA, 1988d). Since substantial emergency remedial actions have been taken at the Lenz Oil site, RI sampling efforts have focused on determining the magnitude and extent of contaminants that remain on-site. The extent of contaminant releases to groundwater and surface water is also investigated.

This baseline risk assessment (RA) includes an evaluation of source and environmental data collected during Phases 1 and 2 of the RI. The risks of adverse human health effects resulting from exposure to site-related contaminants are characterized and quantified. Risks resulting from exposure of ecological receptors to site-related contaminants are also assessed. Risks determined in this RA will be used along with applicable or relevant and appropriate requirements (ARARs) to select one or more of the remedial alternatives identified during a separate FS.

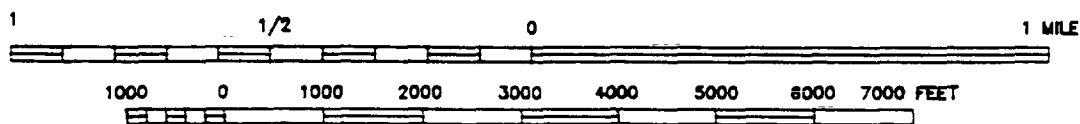
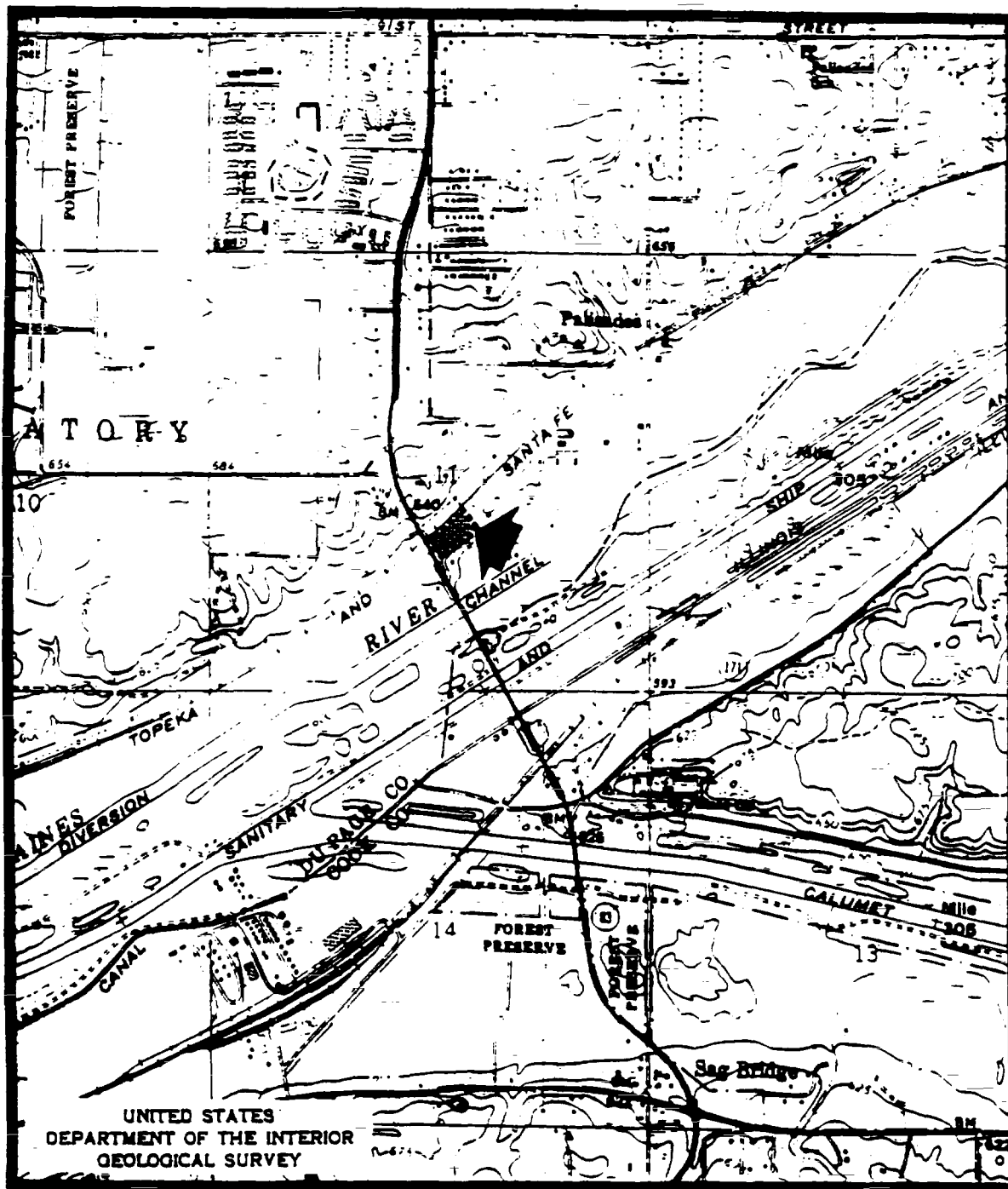
1.2 SITE BACKGROUND

Site background information is derived from the RI/FS support documents prepared for the Lenz Oil site, primarily Technical Memorandum No. 1 (ERM, 1991a). The Lenz Oil site is located northeast of the intersection of Illinois Route 83 and Jeans Road in southeastern DuPage County. The site is approximately 3.5 miles northeast of the center of Lemont, Illinois, and is surrounded by residential, commercial, light industrial, and idle open land areas. The Des Plaines River is located approximately 600 feet southeast of the site. Figures 1-1 and 1-2 show the general location of the Lenz Oil site.

The site was operated by Lenz Oil Service, Inc. (Lenz Oil) for more than 20 years as an oil and solvent storage and transfer facility. Winston Lenz owned and operated the site from 1961 to 1980. Charles Russell purchased Lenz Oil Service, Inc. in 1980 and operated the facility until November of 1985 when operations at the site ceased and the site was abandoned. The facility originally collected waste oils from local businesses, storing the oils in tanks on the site, and

SAO BRIDGE QUADRANGLE
ILLINOIS
7.5 MINUTE SERIES (TOPOGRAPHIC)

N



SCALE 1"=2,000'

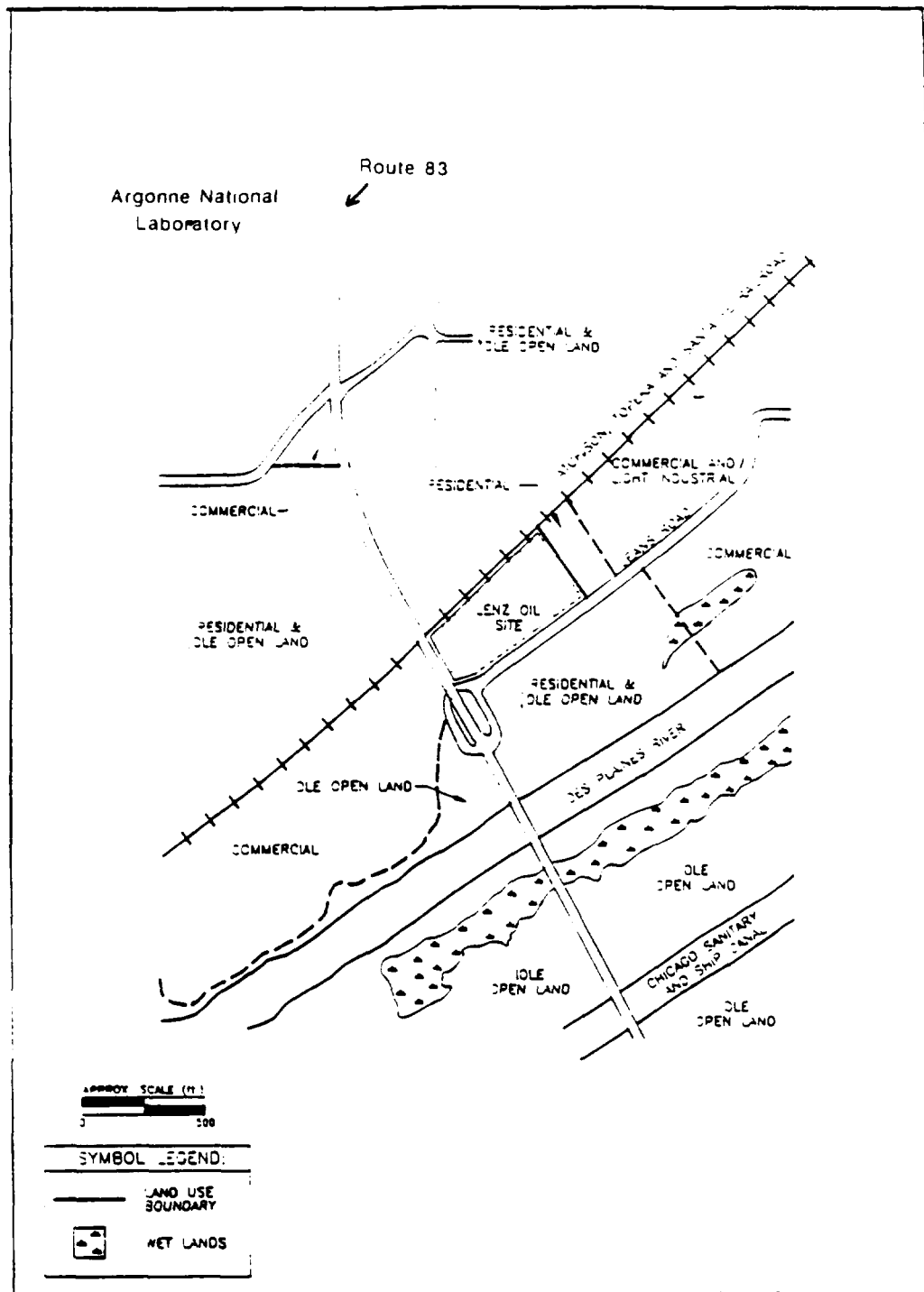


QUADRANGLE LOCATION

LENZ OIL SERVICE SITE
LEMONT, ILLINOIS

FIGURE 1-1
LOCATION MAP

PRC ENVIRONMENTAL MANAGEMENT, INC.



LENZ OIL SERVICE SITE - 06/08/92 - CER - 008-003112

SOURCE: REPRODUCED FROM ERM, 1991

LENZ OIL SERVICE SITE LEMONT, ILLINOIS
FIGURE 1-2 LAND USE MAP
PRC ENVIRONMENTAL MANAGEMENT, INC.

subsequently shipping the oils to local recycling facilities. At some point prior to 1980 the facility owner expanded its operation to include waste solvents. Spent solvents were collected from local commercial and industrial facilities and temporarily stored at the facility in tanks before being shipped to a local recycling facility (ERM, 1991a).

Records from Illinois Environmental Protection Agency (IEPA) regulatory files indicate that the waste types listed in Table 1-1 were accepted by the facility. Operations involving above- and below-ground storage tanks, tanker trucks, drum storage, and surface impoundments were observed on the site in 1985. After numerous violations of their permit to operate a storage and transfer facility (Permit No. 1981-36-DE), an Illinois circuit court ordered Lenz Oil and Charles Russell in May of 1985 to initiate immediate clean-up actions and to file closure and compliance plans. The facility apparently initiated some remedial actions at the site, but in November 1985, IEPA observed that the facility was in general disarray and appeared abandoned (ERM, 1991a).

IEPA initiated their own remedial action at the site in April 1986. Site media were sampled, ground-water monitoring wells were installed, and an emergency remedial action was performed. Approximately 21,000 tons of wastes, drums, and contaminated soils were incinerated. Tanks, tanker trucks, and aboveground and underground structures were removed. Soils were excavated from the main site area and other hotspots down to bedrock and were then incinerated. The ash generated from incineration activities was replaced in the main excavated area on top of a 10-mil (0.01-inch) layer of pond-liner-grade Visqueen.

The Lenz Oil site was listed on EPA's NPL in September 1989, based on site conditions that existed before the IEPA emergency remedial actions. A November 1989 agreement between EPA and Lenz Oil participating respondents required that the RI/FS be performed. This RA evaluates the environmental data collected under Phases 1 and 2 of the ongoing RI/FS. Environmental Resources Management - North Central, Inc. (ERM) is the PRPs RI/FS contractor. Ebasco Services, Inc. (Ebasco) is the Illinois Environmental Protection Agency (IEPA) contractor at this site. Environmental data collected prior to RI activities are not considered in the risk assessment.

Records from Illinois Environmental Protection Agency (IEAP) regulatory files indicate that the waste types listed in Table 1-1 were accepted by the facility. Above- and below-ground storage tanks, tanker trucks, and surface impoundments. Secondary contaminant sources included surface and subsurface soils that were contaminated by releases from the primary sources. During the IEPA emergency remedial action all primary sources and a significant portion of the secondary sources were either removed from the site or incinerated on-site. The ash from the incinerated soil was disposed of on site; this ash may now act as a secondary contaminant source. Figures 1-3 and 1-4 show pre- and post-remediation site features, respectively. The remaining secondary sources and

TABLE 1-1
LENZ OIL SERVICE, INC.
WASTE STREAMS

Waste Types Accepted (1980-1981)

Waste oils

- Motor oil
- Hydraulic oil
- Cutting oil
- Lubricating oil
- Transformer oil

Spent solvents

- Chlorinated solvents
- Oxygenated solvents
- Methyl ethyl ketone
- Toluol
- Ethanol
- Hexane
- Acetate
- Alcohol
- Zylol
- Other nonchlorinated solvents

Pigments

- Unspecified

Inks

- Unspecified

Waste Types Accepted (1984)

Hazardous waste

Nonhazardous waste

- Petroleum hydrocarbons
- Aliphatic hydrocarbons
- Aromatic hydrocarbons
- Chlorinated hydrocarbons
- Aliphatic naphthas
- Aromatic naphthas
- Methylene chloride
- Trichloroethene
- Alcohol
- Naphtha
- Acetone
- 1,1,1-Trichloroethane
- Toluene
- Xylene
- Kerosene
- Methyl ethyl ketone
- Ethyl acetate
- Butanol

Source: ERM, 1991a.

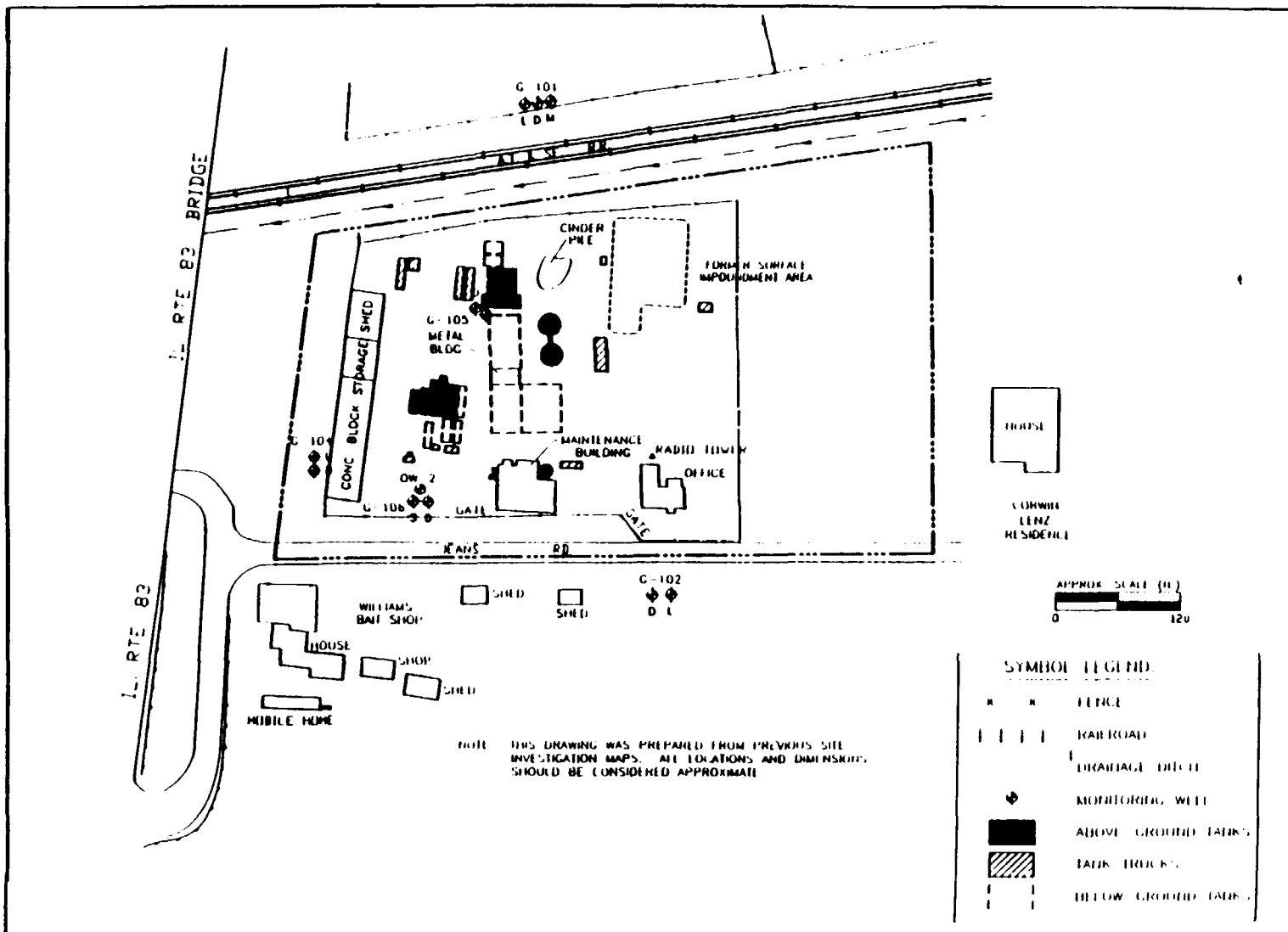
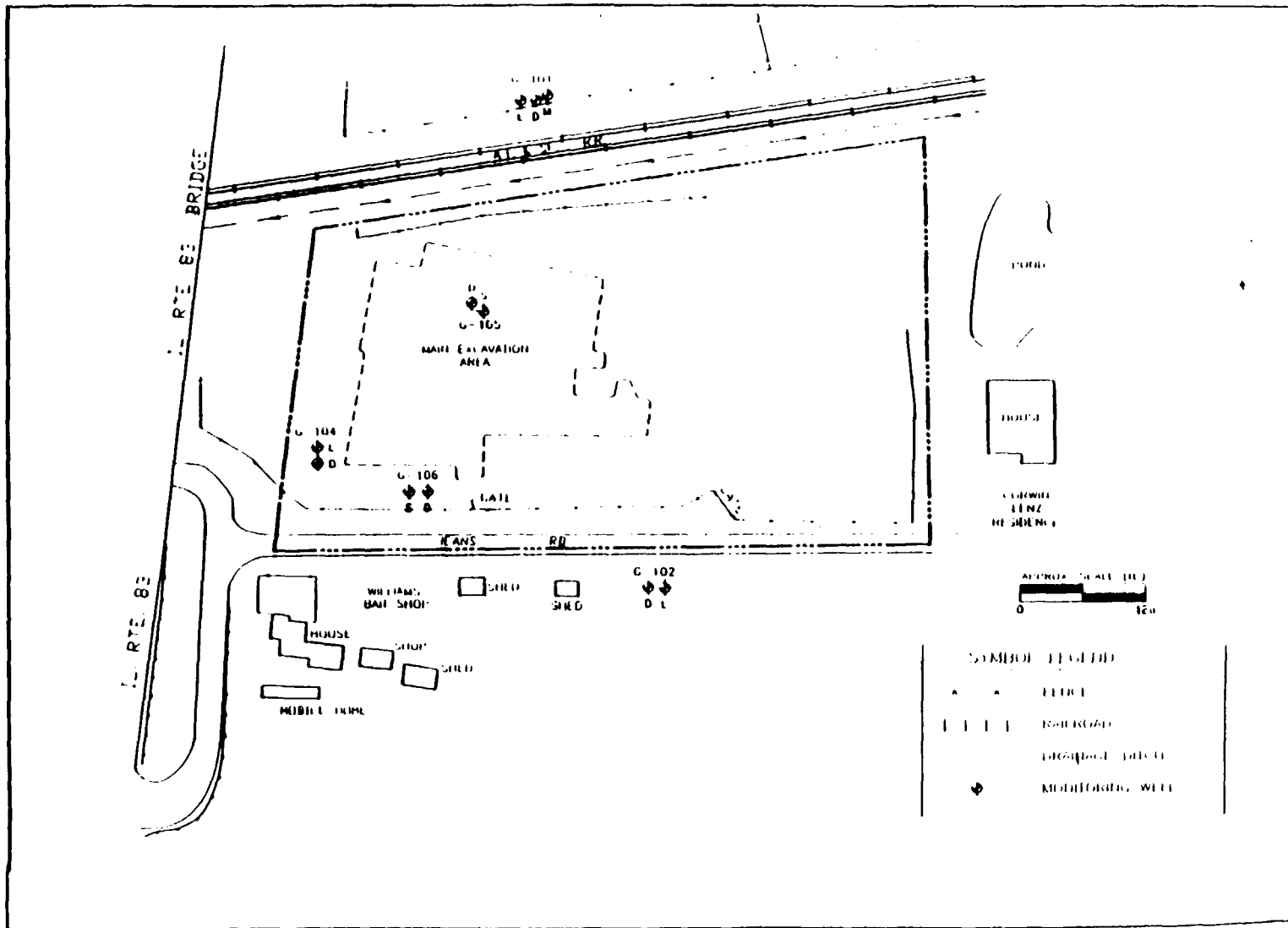


FIGURE 1-3
PRE-REMEDIATION SITE FEATURES

PRC ENVIRONMENTAL MANAGEMENT, INC.



LENZ OIL SERVICE SITE
LEMONT, ILLINOIS

FIGURE 1-4
POST-REMEDIATION SITE FEATURES

PRC ENVIRONMENTAL MANAGEMENT, INC.

their potential for release into groundwater, surface water, air, and direct contact exposure pathways are evaluated in this risk assessment. A conceptual site model for Lenz Oil secondary sources is illustrated in Figure 1-5. Potential transport mechanisms, exposure pathways, and receptors are incorporated into the conceptual model.

As noted, environmental data considered in the RA were collected during Phases 1 and 2 of the RI. In Phase 1, surface soil, subsurface soil, surface water, and sediment samples were collected on and adjacent to the site during January and February of 1991. Soil samples were collected from the area that had been backfilled with incinerated soil ash and the outlying site area where no soil remediation occurred. Ground-water samples were collected from monitoring wells during May 1991.

In Phase 2, ground-water samples were collected from residential and monitoring wells and non-aqueous-phase liquids were collected from monitoring wells in February 1992. Nearby residential wells are used for nonpotable purposes only. Surface water and soil samples were also collected in February 1992. The surface water samples were collected from the same locations as surface water samples collected during Phase 1. Soil samples were collected from the incinerator process area along the eastern edge of the site and from other areas sampled during Phase 1. The number and locations of Phase 1 and Phase 2 samples are described in Section 2.3 of this report.

1.3 SCOPE OF RISK ASSESSMENT

The RA characterizes and quantifies the risks of adverse human health effects resulting from exposure to site-related contamination, assuming no additional remedial action is taken at the site. Risks resulting from exposure of ecological receptors to site-related contaminants are also assessed using the same assumption. The environmental data collected during the RI are evaluated in Section 2.0. Data qualifiers, site background, and additional data usability issues are also considered. Section 3.0 presents the exposure assessment which evaluates contaminant sources, release mechanisms, migration and exposure pathways, and potential human and ecological receptors. The exposure assessment also determines the potential intake of contaminants by human populations.

Toxicity profiles of specific contaminants and EPA toxicity values used in the quantitative risk assessment are summarized in Section 4.0. The toxicity and exposure assessments are then interpreted in Section 5.0 to characterize carcinogenic and noncarcinogenic risks at the site. The major assumptions and uncertainties associated with the risk assessment are identified and discussed in Section 6.0. Potential impacts on ecological receptors are assessed in Section 7.0.

FIG. 5
CONCEPTUAL MODEL
LENNZ OIL SPILL, SECONDARY SOURCES

Media Receiving Contamination	Potential Transport Mechanisms	Exposure		Human Receptors				Environmental Receptors	
		Media	Route	Land Use				Aquatic	Terrestrial
				R	I	Re	W		
Soil/Ash	→ None →	Soil	Ingestion Dermal	• •		• •	• •		• •
	→ Wind Erosion →	Air	Inhalation	•	•	•	•		
	→ Volatile Emissions →								
	→ Infiltration →	Ground-water	Ingestion Dermal Inhalation	• • •					
	↓								
	→ Groundwater Transport →	Surface Water	Ingestion Dermal Inhalation			• •		• •	• •
	→ Overland Surface Water Flow →	Sediments	Dermal			•		• •	• •
	↓								
	Deposition To Sediments →	Biota	Ingestion (Fish Plant/Crop)	• •		•			
	→ Deposition →								
	→ Biotic Uptake →								

= Residential

Re = Recreational

= Industrial

W = Future Short-Term Construction

2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

2.1 HISTORICAL DATA

As noted in Section 1.2, this RA evaluates the environmental data collected under Phases 1 and 2 of the ongoing RI/FS. Environmental data collected prior to RI activities are not quantitatively evaluated. The historical data are, however, summarized briefly in the following paragraphs to characterize the initial on-site primary and secondary contaminant sources.

IEPA initiated emergency remedial action in 1986, which included sampling of waste materials, soils, groundwater, and ash. Contaminants detected in drums, tanks, tanker trucks, and the surface impoundment included metals, cyanide, semivolatile organic compounds (SVOC), volatile organic compounds (VOC), and polychlorinated biphenyls (PCBs). Poor operating procedures and inadequate housekeeping practices resulted in contaminant releases from these primary sources to on-site soils. Soil samples revealed contaminants similar to those detected in the primary sources. The ash from soils incinerated during the emergency remediation was used to backfill the main on-site excavation area. Samples from ash material revealed some SVOC and VOC. Specific contaminants detected by IEPA in the primary (soil samples) and secondary (ash samples) source areas are summarized and presented in table form in Technical Memorandum Number 1 of the RI (ERM, 1991a). These data summary tables are also included in Appendix A of this report.

IEPA ground-water sampling data indicated that the groundwater is a significant contaminant migration pathway. Acetone, chloroethane, benzene, ethylbenzene, and xylene were detected in samples taken from private wells near the site between 1985 and 1987. Volatile and semivolatile organic compounds were detected in monitoring well samples taken from 1986 to 1987. These data are also summarized in Technical Memorandum Number 1 (ERM, 1991a), and the data summary tables are included in Appendix A of this report (see Tables 4-7 and 4-8). Technical Memorandum Number 1 indicates that municipal water service was provided to all residences in the vicinity of the Lenz Oil site during IEPA remedial activities in 1988. However, nonpotable uses of well water are apparently continuing in the site vicinity (ERM, 1991b, 1992b).

The historical data did not address other potential migration pathways from the site (such as surface water, sediments, and air). Surface water runoff from the site can either infiltrate the soil and migrate to groundwater, or migrate overland to the Des Plaines River. An ephemeral drainage ditch receives runoff from the northern portion of the site and eventually discharges to the river approximately 1 mile southwest of the site. Contaminants may also be released to the air through volatilization and wind-borne particulates. Migration pathways are assessed in Section 3.0 of this report.

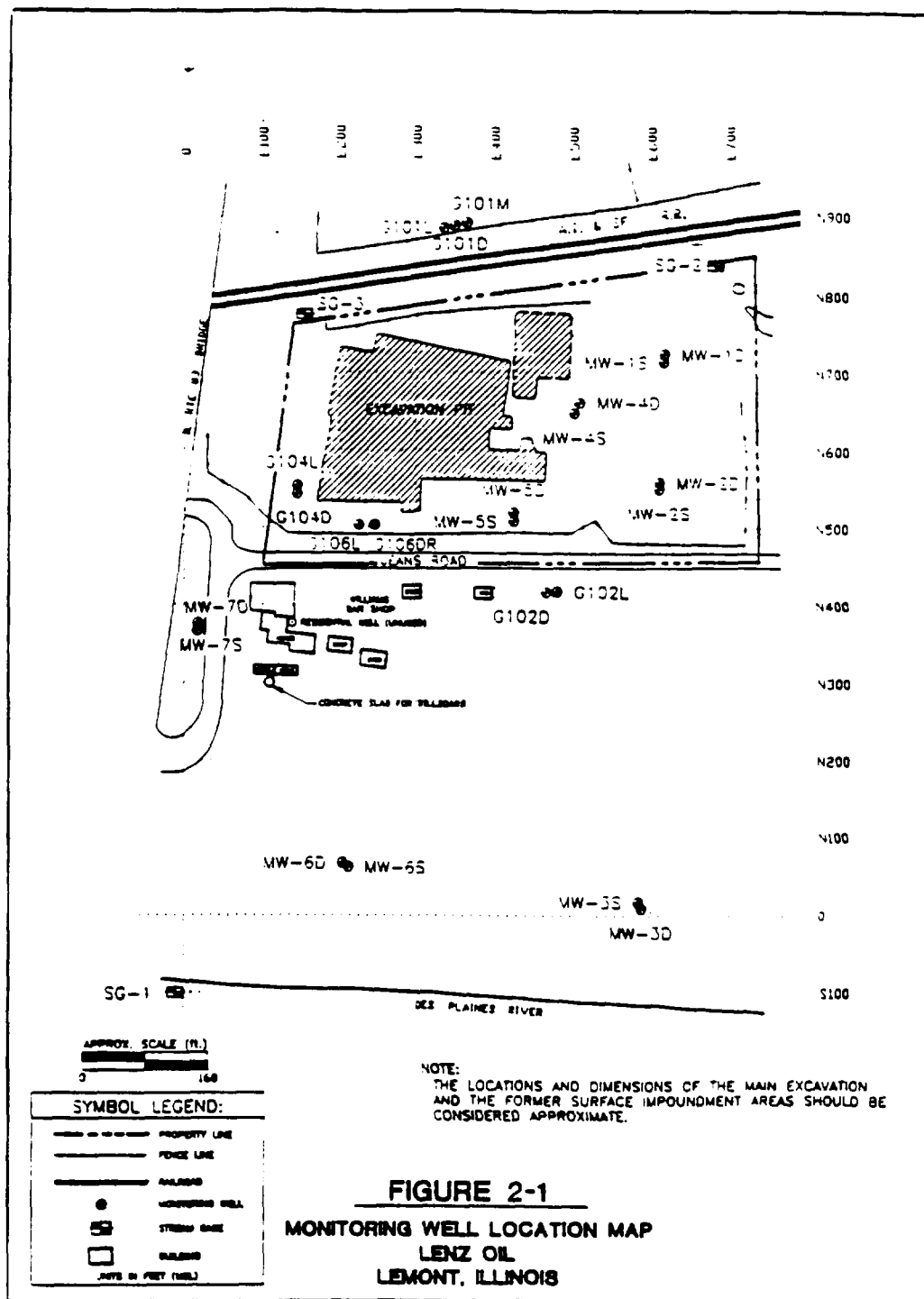
2.2 BACKGROUND SAMPLING

Ground-water, surface water, and soil background samples were taken during Phase 1 and Phase 2 sampling activities (see Figures 2-1 and 2-2). Monitoring well cluster G101 was designated as indicative of background contaminated levels based on its location northwest and hydrologically upgradient of the site. However, because the deep samples from G101 showed contamination with organic constituents, they were not used to establish background for deep ground water. Instead, PRC used deep samples from monitoring well MW-7 to establish background concentrations for deep ground water because MW-7 is along the western edge of the site and did not appear to be affected by the site based on previous sampling results. Surface water sampling points SW01 and sediment sampling point SD01 were designated as indicative of background contaminant levels based on its location just upgradient to the site in the drainage ditch. Three soil sampling locations (SB213, SB214, and SB215) were selected as background indicators based on their location in an open field northwest of the site across the Atchison, Topeka, and Sante Fe railroad. The sampling data for these background locations are described and compared to site conditions in Sections 2.4 and 2.5 of this report.

2.3 SAMPLE APPROACH AND DATA QUALITY OBJECTIVES

Ground-water, surface soil, subsurface soil, surface water, sediment, ash, and quality assurance/quality control (QA/QC) samples were obtained and analyzed during Phases 1 and 2 of the RI. Samples were analyzed for target compound list (TCL) organic compounds and target analyte list (TAL) inorganic compounds. Samples were analyzed in a manner consistent with routine analytical services (RAS) contract laboratory program (CLP) or SW846 procedures, with the exception of domestic well samples which were analyzed following special analytical services (SAS) procedures.

Selected soil samples were also analyzed for toxicity characteristic leachate procedure (TCLP) metals. Soil gas was also sampled to evaluate the areal distribution of volatile organic contamination downgradient of the site and to support monitoring well placement. Soil gas samples were analyzed for selected volatile organic compounds using non-CLP methods. Other physical parameters were measured to facilitate data interpretation and fate and transport analyses. These included pH, specific conductivity, and temperature of water samples; organic vapor concentrations of soils, sediments, and soil gases; and particulate size, total porosity, total organic content, water level, and hydraulic conductivity of aquifer materials.



LENZ OIL SERVICE SITE
LEMONT, ILLINOIS

FIGURE 2-1
MONITORING WELL LOCATION MAP

PRC ENVIRONMENTAL MANAGEMENT, INC.

LENZ OIL SVC - 07/13/92 - CTR - 009-605112

Only sample data analyzed following RAS procedures and validated through a quality assurance review are quantitatively evaluated in the RA. Sample locations and collection methods are described in the RI/FS sampling and analysis plans (ERM, 1990). The number and location of samples, as defined in these sampling plans, are discussed in Sections 2.3.1 through 2.3.3 below. Data validation is discussed in Section 2.3.4.

2.3.1 Groundwater Sampling

A total of 15 monitoring wells were installed at the site during the RI, including seven 2-well clusters and one deep well. The wells either supplemented or replaced components of an existing monitoring well network of one 3-well cluster and four 2-well clusters. The resulting network consists of shallow, medium, and deep wells, clustered upgradient and varying distances downgradient of the source area. The purpose of the monitoring well network is to determine the magnitude and extent of ground-water contamination emanating from the Lenz Oil site. Ground-water sample results are used in the RA to evaluate potential current and future impacts on groundwater users. The locations of ground-water monitoring wells are shown in Figure 2-1. Because ground-water flow at the site was poorly defined in Phase I, no ground-water flow direction is indicated in the figure.

Phase 1 included one round of ground-water sampling of on- and off-site monitoring wells. Phase 2 included a second round of groundwater sampling of on- and off-site monitoring wells, and sampling of residential wells for analyses using SAS procedures to achieve low detection limits. The nonaqueous phase liquid (NAPL) layer present on groundwater at the site was also sampled in two monitoring wells during Phase 2. These NAPL samples were analyzed for TCLP organics and inorganics, as well as for TCL and TAL compounds. The NAPL layer is treated as a separate medium from groundwater; however, risks potentially resulting from residential use of this layer are not assessed.

2.3.2 Soil and Sediment Sampling

Surface and subsurface soil samples were collected during Phase 1 to determine the magnitude and extent of soil contamination. Samples from the main excavation area were collected to assess the adequacy of the previous emergency remedial activities. Soil samples were collected in areas of potential contamination to determine the magnitude and extent of contamination outside the main excavation area. The locations of Phase 1 soil borings are shown on Figure 2-2.

During Phase 2, 19 soil boring locations were sampled. Twelve samples were taken in areas not previously sampled, including the former incinerator system area and an area along the southeastern

part of the site. Four samples were taken from areas previously sampled during Phase 1, and three background samples were taken. The locations of Phase 2 soil borings are also shown in Figure 2-2.

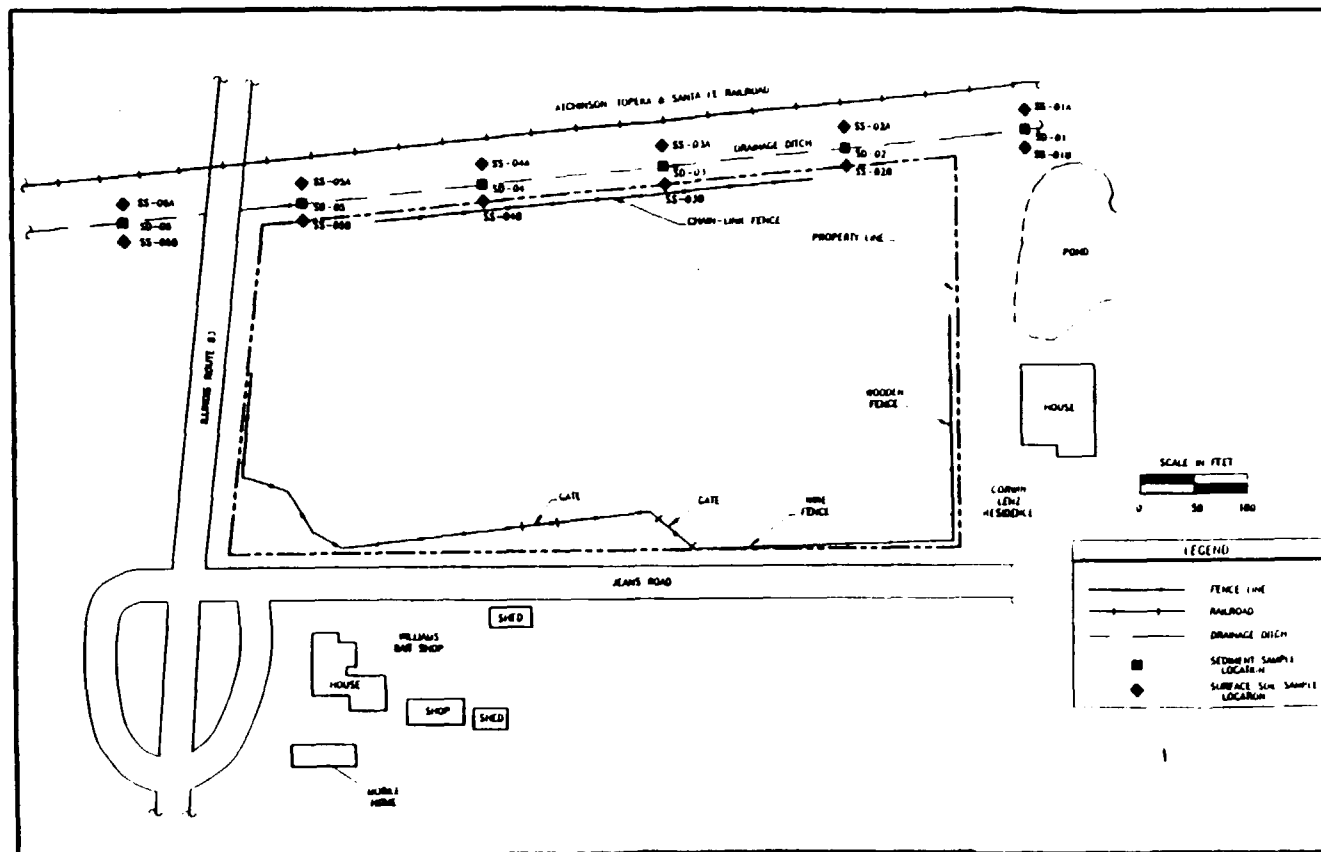
Phase 1 and Phase 2 soil samples were taken from the main excavation area that had been backfilled with incinerated soil ash and from outlying areas. Shallow borings in the excavated area were collected to determine the chemical nature of the ash. Deep ash samples were collected in the excavated area to determine if the Visqueen liner was intact or if intruding groundwater had contaminated the ash. The locations of borings in the excavated and outlying areas shown on Figure 2-2. The two areas are considered to represent distinct media in the RA.

Because no surface soil were collected in the top 6 inches of soil on the site, shallow soil boring samples taken on site from depths ranging from 0 to 5 feet are used to assess risks from direct contact with soils and to predict wind-borne particulate emissions and associated risks. As a result, using samples from these depths may overestimate exposure point concentrations to chemicals in surface soil. Subsurface and surface soil sample data are used to predict vapor emissions to the air and to assess risks from direct contact with soils during any excavation activities.

Six sediment and 12 off-site surface soil samples were collected during Phase 1 along the drainage ditch northwest of the site to evaluate potential release of contaminants to the drainage system. The sediment samples were collected upgradient, adjacent to, and downgradient of the site. Soil samples were collected from the north and south banks of the drainage ditch adjacent to each sediment sampling point in order to determine if contaminants had entered the drainage ditch from either the site, a source upgradient of the site, or a source across the ditch from the site. The sediment data are used to assess risks from direct contact with sediments. Surface soil data from the ditch are quantitatively evaluated. The locations of off-site soil and sediment drainage ditch samples are shown on Figure 2-3.

2.3.3 Surface Water Sampling

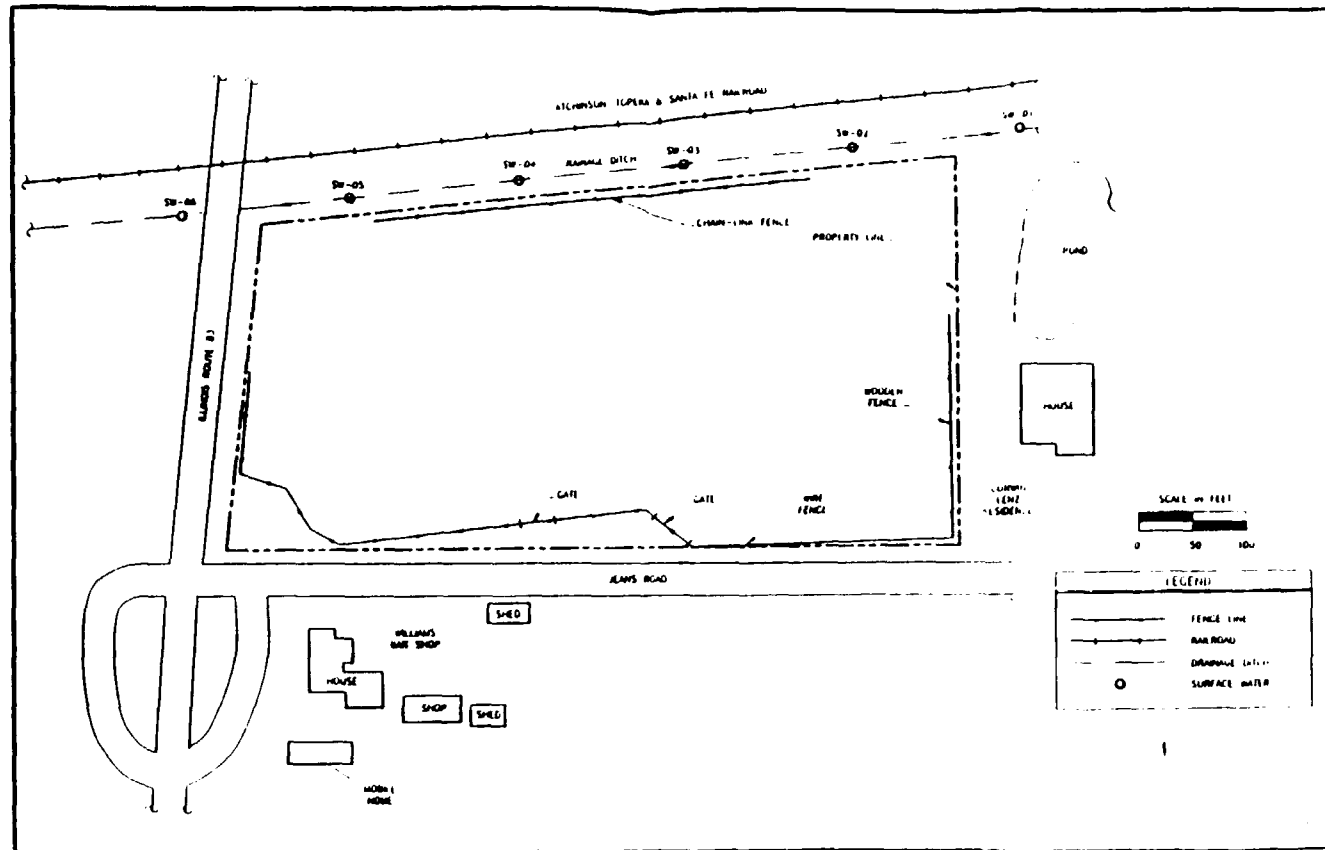
Six surface water samples were collected during Phase 1 from the drainage ditch at the same locations as the sediment samples. These samples were collected to evaluate potential releases of contaminants into the drainage system. The surface water data are used to assess risks from direct contact with and ingestion of surface water. The locations of surface water samples are shown on Figure 2-4. Because of data validation concerns relating to inorganic results, the six surface water locations were resampled during Phase 2. Phase 2 samples were analyzed for inorganic compounds.



LENZ OIL SERVICE SITE
LEMONT, ILLINOIS

FIGURE 2-3
OFF-SITE SOIL AND SEDIMENT
SAMPLING LOCATIONS

PNC ENVIRONMENTAL MANAGEMENT, INC.



LENZ OIL SERVICE SITE
LEMONT, ILLINOIS

FIGURE 2-4
SURFACE WATER SAMPLING LOCATIONS

PRC ENVIRONMENTAL MANAGEMENT, INC.

2.3.4 Validation of Sample Data

Data were validated for Phase 1 ground-water sampling using EPA guidelines for evaluating organic analyses (EPA, 1988a) and inorganic analyses (EPA, 1988c). ERM (1992a) reported that all Phase 1 ground-water data were determined to be invalid with the exception of the volatile organic compound (VOC) analyses. Phase 1 ground-water analytical results are limited to the valid or estimated VOCs that were detected. ERM (1992c) also reported that data were validated for Phase 2 ground-water sampling using EPA guidelines for evaluating organic analytes (EPA, 1991a) and inorganic analytes (EPA, 1988c). Approximately 20 percent of the Phase 2 ground-water data validation results were reviewed by PRC. No errors impacting data quality and useability were identified (PRC, 1992b).

Phase 1 surface water, sediments, and soil data were validated according to the EPA Region II Standard Operating Procedures (SOP) #HW-6 for organics and SOP #HW-2 for inorganics (as cited in Ebasco, 1992). Serious analytical deficiencies were noted for inductively coupled plasma metal analyses. Soil and sediment samples were reanalyzed and validated, but surface water sample analyses are considered to be estimated. Surface water samples were taken from the same six locations in Phase 2 and validated by IEPA (ERM, 1992c). Soil samples collected during Phase 2 were also validated by IEPA (ERM, 1992c). PRC reviewed the data validation reports for the Phase 2 surface water and soil samples (PRC, 1992b). No errors impacting data quality and useability were identified.

2.4 DATA EVALUATION

This section identifies the chemicals found at the Lenz Oil site that are of potential concern to humans and the environment. These chemicals are referred to as the chemicals of potential concern. Data collection is addressed first, followed by a discussion of the criteria used to evaluate the data.

2.4.1 Data Collection

As discussed earlier in this report, samples were collected from various media at the site during Phase 1 and Phase 2 of the RI. The RI involved sampling and assays to determine contaminant concentrations. The following media were sampled and are listed with the phase in which each sample was obtained in and the document from which sample results were obtained:

- Groundwater sampling (Phases 1 and 2; ERM, 1992a,c)
- Surface water sampling (Phases 1 and 2; Ebasco, 1992 and ERM, 1992c)
- Sediment sampling (Phase 1; Ebasco, 1992)

- Surface and subsurface soil sampling (Phases 1 and 2; Ebasco, 1992 and ERM, 1992c)
- Soil gas sampling (Phase 1; ERM, 1991b)

For analyzing organics in various samples, the gas chromatography/mass spectrometry (GC/MS) method was used. For the RA analysis, PRC used analytical results obtained from Phase 2 ground-water samples for organics and Phase 2 unfiltered ground-water samples for inorganics. Samples from all depths of the shallow aquifer were considered for this RA because current and future residential and commercial well screens may draw from the entire depth of the aquifer.

For the RA, surface soil samples were defined as those collected at depths ranging from 0 to 5 feet. Samples taken from the total soil column included surface soil samples as well as subsurface samples collected at depths up to 9 feet.

PRC did not qualitatively address the soil gas sampling in this risk assessment.

2.4.2 Data Evaluation in Selecting Chemicals of Potential Concern

PRC followed U.S. EPA guidance (EPA, 1989b) for selecting the chemicals of potential concern. The procedure used to select these chemicals of potential concern is based on criteria discussed in the following sections.

2.4.2.1 Frequency of Detection.

If the contaminant was detected in some but not all samples within a medium, then one-half of the sample quantitation limit (SQL) is substituted for samples points that were nondetects. However, several samples were excluded from the estimation of exposure point concentrations because they had unusually elevated SQLs that resulted in exposure point concentration estimates greatly exceeding the maximum detected concentrations. Contaminants that were not detected in at least 20 percent of the samples and did not pose significant risks in soil ingestion and dermal contact assessments (that is, less than 10^{-8} risks) were not assessed in the air pathway.

2.4.2.2 Comparison with Background Levels.

Statistical tests were conducted using data results from site-related sampling points and sample points corresponding to background locations. The purpose of these tests was to establish which compounds encountered in the samples were attributable to contamination at the site, and to separate these compounds from others naturally present in the environment.

Background samples for soils (three locations), surface water and sediment (one location), and groundwater (one location, well cluster G101) were collected. However, volatile organic compounds were detected in the deep well (G101d) within background well cluster G101 during Phase 1 sampling. For the RA, ground-water results from wells G101s and G101m were used to represent background conditions for shallow ground water. However, because G101d showed organic contamination and might be impacted by the site, ground-water results from well MW-7d were used to represent background conditions for deep ground water.

PRC chose to use the statistical comparison between the on-site soil samples and the three background soil samples to determine which inorganic compounds are potentially site-related. PRC believes that soil sampling data provide the best indication of background conditions based on the significant number of soil samples collected on the site and the collection of three discrete background soil samples. A description of the statistical approach used for background comparisons is included in Appendix B. The comparison indicates that the following inorganic compounds are present on the site at concentrations above those found in the three background samples:

- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Lead
- Magnesium
- Zinc

PRC considered these inorganic compounds to be potentially site-related and evaluated them quantitatively in the RA for all media in which they were detected. However, since calcium and magnesium are essential human nutrients, these compounds are not included in the quantitative risk assessment. Because VOCs are not naturally occurring substances, no VOCs were excluded from the RA based on background comparisons.

2.4.2.3 Data Qualifiers.

CLP qualifiers and codes attached to analytical data by laboratories or data validators are evaluated. In general, data with qualifiers that indicated uncertainties in concentrations but not in identification

are included in the RA. Data with qualifiers that indicate uncertainties in chemical identification (that is, qualifiers "A" and "R") are dropped from the quantitative risk assessment.

Analytes detected in blank samples are evaluated. Sample results are considered in the quantitative risk assessment if they are present at concentrations that exceed 10 times the maximum concentrations of common laboratory contaminants or 5 times the concentrations of other blank contaminants.

2.4.2.4 Availability of Carcinogenic Slope Factors (CSF) or Reference Dose Values (RfD)

Toxicological data sufficient for quantification of risk for several chemicals of potential concern were not available. Therefore, exposures to and risks from these chemicals were not quantitatively evaluated. These chemicals are listed in Section 4.0.

2.4.2.5 Tentatively Identified Compounds (TICs)

A significant number of TICs were detected during Phase 1 and Phase 2 sampling. Because no toxicity values are available for TICs, these compounds are not included in the quantitative risk assessment. TICs are qualitatively evaluated in Section 4.0. It should be noted that concentrations of unknown compounds were also detected during the RI sampling.

2.4.2.6 Uncertainty

The primary uncertainty associated with data from the Lenz Oil site is that ground-water data used for this RA were obtained during only a single quarter of sampling. Also, the surface water organic data are based on Phase 1 sampling, while the surface water inorganic data are based on Phase 2 sampling results. Variations in the number of contaminants and their concentrations may have occurred, but have not been accounted for in this RA.

Data used to calculate risks from inhaling contaminants in the air resulting from volatilization of organics during showering or fugitive dusts and vapors released from soils were estimates derived using different models. There is a level of uncertainty associated with assumptions used in these models.

2.4.3 Chemicals of Potential Concern in Environmental Media

PRC divided the Lenz Oil site into four point source areas (two for groundwater and two for soil), as well as surface water and sediment sampling areas for identification of chemicals of potential concern. These areas include the following:

- Groundwater Area A -- Based on groundwater samples taken on site and within the groundwater contaminant plume
- Groundwater Area B -- Based on groundwater samples taken off site and within the groundwater contaminant plume
- Soil boring Area A -- Based on soil borings taken on site and within the boundaries of the soil previously excavated for incineration
- Soil boring Area B -- Based on soil borings taken on site and outside of the boundaries of soil previously excavated for incineration
- Surface water and sediment sampling areas

Because significant differences in contaminant concentrations were identified between on-site and off-site groundwater samples, PRC divided the site into two distinct exposure areas to evaluate groundwater exposure. Also, because significant differences in contaminant concentrations were identified between shallow and deep ground water sampled at the site, risks were considered separately for the upper and lower portions of the shallow aquifer.

Risks from exposure to surface soils that may occur in residential, trespasser, and short-term worker scenarios were also considered. Exposure point concentrations in surface soil were estimated using samples taken from between 0 and 5 feet in depth. Potential organic compound emissions that may occur from contamination in the entire soil column were also considered. Exposure point concentration in the total soil column were estimated using samples taken from between 0 and 9 feet in depth.

Surface soil samples were taken from the banks of the drainage ditch but were not considered to represent a distinct exposure area and were considered qualitatively.

A single distinct surface water body, the drainage ditch, was identified on the site and sampled for identification of chemicals of potential concern in surface water and sediment.

The locations of sample points for these areas are shown on Figures 2-1 through 2-4. The arithmetic mean and 95 percent upperbound confidence limit value about the arithmetic mean were calculated

for the groups of samples in each medium, following EPA guidance (EPA, 1989b) for all calculations. The results for each medium are listed in Appendix C.

2.5 SUMMARY OF CHEMICALS OF POTENTIAL CONCERN

Table 2-1 presents the chemicals of potential concern by medium and area. The results demonstrate that a significant number of volatile and semi-volatile organic compounds, as well as a smaller number of inorganic compounds, are present in the soils, groundwater, and sediments associated with the Lenz Oil site. A quantitative risk was assessed for all chemicals listed that have toxicity values. A discussion of the contaminants of concern based on carcinogenic and noncarcinogenic risk is included in Section 5.0.

To assess risk, reasonable maximum exposure (RME) concentrations are assigned to each chemical. RME concentrations correspond to the highest exposure that is reasonably expected at the site. Because of the uncertainty associated with any estimate of exposure concentration, EPA documentation (1989b) recommends that the upper confidence limit (that is, the 95 percent upper confidence limit) on the arithmetic average be used as the RME exposure concentration. The 95 percent upper confidence limits for chemicals of concern are listed as the RME concentration for each medium unless this exceeds the maximum detected concentration. If this occurs the maximum detected concentration is considered the RME concentration. The RME exposure concentrations are used to estimate chemical intakes in the following exposure assessment.

TABLE 2-1
CHEMICALS OF POTENTIAL CONCERN (CPC)
LENZ OIL SERVICE SITE

CHEMICAL	MEDIA:	GW				SS		SB		SSD		SW	SD
	AREA:	A	A	B	B	A	B	A	B	A	B	NA	NA
	UNIT:	U	L	U	L	NA	NA	NA	NA	NA	NA	NA	NA
ORGANICS													
VINYL CHLORIDE		-	-	X ^a	X	-	-	-	-	-	-	-	-
CHLOROETHANE		X	X	X	-	-	-	-	-	-	-	-	-
METHYLENE CHLORIDE		X	-	-	-	X	X	X	X	-	-	-	-
ACETONE		X	-	-	-	-	X	X	X	-	X	-	X
CARBON DISULFIDE		-	-	-	-	-	-	X	-	-	-	-	-
1,1-DICHLOROETHENE		X	-	X	X	-	-	-	X	-	-	-	-
1,1-DICHLOROETHANE		X	-	X	X	X	X	X	-	-	-	-	-
1,2-DICHLOROETHENE		X	-	X	X	-	X	-	X	-	-	-	-
CHLOROFORM		X	-	-	-	-	-	-	X	-	-	-	-
1,2-DICHLOROETHANE		-	-	-	-	-	-	X	-	X	-	-	-
2-BUTANONE		-	-	-	-	-	-	X	-	-	-	-	-
1,1,1-TRICHLOROETHANE		-	-	X	X	X	X	X	X	-	-	-	-
1,1,2,2-TETRACHLOROETHANE		-	-	X	-	-	-	-	X	-	-	-	-
TRANS-1,3-DICHLOROPROPENE		-	-	-	-	-	X	X	X	-	-	-	-
TRICHLOROETHENE		X	-	X	-	X	X	X	X	-	X	-	-
BENZENE		X	X	-	-	X	X	X	-	-	-	-	-
4-METHYL-2-PENTANONE		-	-	-	-	-	X	-	X	-	-	-	-
TETRACHLOROETHENE		-	-	X	-	X	X	X	X	-	X	-	-
TOLUENE		X	X	-	-	X	X	X	X	-	X	-	-
ETHYLBENZENE		X	-	-	-	X	X	X	X	-	X	-	-
XYLENES (TOTAL)		X	-	-	-	X	X	X	X	-	X	-	X
PHENOL		-	-	-	-	-	-	X	-	-	-	-	-
1,2-DICHLOROBENZENE		-	-	-	-	X	-	X	-	-	-	-	-
NAPHTHALENE		X	-	-	-	X	X	X	X	X	X	-	X
2-METHYLNAPHTHALENE		X	-	-	-	X	X	X	X	X	X	-	X
HEXACHLOROCYCLOPENTADIENE		-	-	-	-	-	-	-	X	-	-	-	-
ACENAPHTHALENE		-	-	-	-	X	-	-	-	-	-	-	-
ACENAPHTHENE		-	-	-	-	-	-	-	X	-	-	-	-
DIBENZOFURAN		X	-	-	-	X	X	X	X	X	X	-	X
DIETHYLPHTHALATE		-	X	-	-	-	-	-	-	-	-	-	-
FLUORENE		X	-	-	-	X	X	X	X	-	X	-	X
PENTACHLOROPHENOL		-	-	-	-	-	-	-	X	-	-	-	-
PHENANTHRENE		X	-	-	-	X	X	X	X	X	X	-	-
ANTHRACENE		-	-	-	-	X	X	X	X	X	X	-	-
DI-N-BUTYLPHTHALATE		X	X	X	X	-	-	X	X	-	-	-	-

LENZ OIL SERVICE SITE

Notes:	GW = ground water	SS = surface soil	SB = soil boring	SSD = surface soil from drainage ditch
	SW = surface water	SD = sediment	NA = not applicable	bank
	Chemical is not of potential concern in particular media			
	Chemical is of potential concern in particular media			

3.0 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to estimate the possible chemical intakes for each complete exposure pathway. Sections 3.1, 3.2, and 3.3 qualitatively document the physical setting of the Lenz Oil site, the populations potentially exposed to site contaminants, and the exposure pathways related to the site, respectively. Section 3.4 quantitatively estimates chemical intakes for potentially exposed populations. Section 3.5 identifies uncertainties and Section 3.6 summarizes the exposure assessment.

3.1 PHYSICAL SETTING

The physical setting of the Lenz Oil site is described in Technical Memorandum No. 1 (ERM, 1991a). The following description of the site physiography, surface water hydrology, and geology is excerpted from Section 2.0 of that report.

3.1.1 Physiography

The Lenz Oil site is located in the flood plain of the Des Plaines River at the base of a 75-foot bluff. The Des Plaines River is about 600 feet southeast of the site, and the Chicago Sanitary and Ship Canal is an additional 800 feet southeast of the Des Plaines River. The report describes the regional slope as southeast toward the river, but because of earlier site grading, part of the site slopes northwest toward a transient drainage ditch.

According to the report, the Lenz Oil site is located in the Wheaton Morainal County subsection of the Great Lakes section of the Central Lowland physiographic province. The area encompassing the site is described as undulating uplands with drainage channels and rivers. The Des Plaines River cuts through the rough knob and kettle topography of the Valparaiso Morainic system. In some areas along the Des Plaines River, erosion has removed glacial deposits and exposed the underlying bedrock.

3.1.2 Surface Water Hydrology

Surface water runoff from the site either infiltrates the soil or discharges to the Des Plaines River. The drainage ditch on the northwest border of the site receives runoff from the northern half of the site and an area northwest of the site. The drainage ditch runs through the auto wrecking facility southwest of the site and eventually discharges to the Des Plaines River. Surface water in the Des Plaines River Valley flows to the southwest and eventually flows into the Mississippi River.

The Des Plaines River discharge in the site area (i.e., Riverside gage) ranged in 1989 from 147 cubic feet per second (cfs) to 3,720 cfs. The maximum flow of the Des Plaines River measured at this gage was 9,770 cfs in 1943. The Chicago Sanitary and Ship Canal discharge measured at the Romeoville gage (about 6 miles downstream from the Lenz Oil site) ranged from 1,790 cfs to 12,800 cfs in 1989, with a maximum recorded flow of 16,300 cfs in 1974. The upland areas surrounding the site contain pot-hole lakes. Wetland areas are located in the Des Plaines River Valley, but no permanent surface water bodies are located on the site.

3.1.3 Geology

The geology of southeastern DuPage County is described as a "thick sequence of Silurian bedrock overlain by Quaternary glacial drift and alluvial deposits . . . The uppermost bedrock in the study area is Silurian dolomite of the Racine Formation, which is the uppermost unit in the Niagaran Series." Previous site investigations indicate that the Racine dolomite was encountered 6.0 to 24.5 feet below ground surface (bgs). The bedrock was described as rubbly at the top and fractured throughout the encountered interval. The bedrock surface becomes shallower toward the southeast, but is described as extremely irregular on a small scale. The report interprets the silty dolomitic gravel that overlies the dolomitic bedrock as weathered dolomite that has escaped erosion and redeposition. The silt, containing sand, clay, and gravel, which overlies the weathered dolomite, is believed to be alluvial deposits (Holocene alluvium) associated with the Des Plaines River.

The Holocene alluvium and Silurian dolomite are partially hydraulically connected and act as a single unconfined aquifer with a total saturated thickness of approximately 150 to 200 feet. Previous sampling at the site has shown a significant difference between chemical concentrations detected in shallow and deep wells. This aquifer is recharged primarily by precipitation and exhibits seasonal fluctuations in the water table elevation. The saturated thickness of the unconsolidated deposits ranges from 20.5 feet on the site to 1 foot near the Des Plaines River. The hydraulic conductivity of the unconsolidated deposits ranges from 178 to 4,102.5 gallons/day-square foot. The average hydraulic gradient within the surficial aquifer is approximately 0.0048 foot/foot toward the southeast (towards the Des Plaines River). Shallow ground-water flow direction appears to shift near the drainage ditch. The direction or cause of this shift is not certain.

3.1.4 Climate

The following summary is based on Chicago, O'Hare International Airport, Illinois, climatological data (NOAA, 1990). Specific meteorological information is not available for the Lenz Oil site, and local conditions in the Des Plaines River Valley may be different.

Based on the 1951 to 1980 record period, the normal annual precipitation for the area is 33.3 inches. Precipitation falls throughout the year and snow is prevalent December through March, totaling 21.4 inches in 1990. The Chicago area is characterized by temperature extremes. January exhibits the lowest normal daily minimum temperature at 13.6° F, while July shows the highest normal maximum temperature at 83.3° F. A -27° F record low occurred during January 1985, and a record high of 104° F occurred during June 1988.

Yearly windspeeds for the 1951 to 1980 period averaged 10.3 miles per hour (mph). The lowest monthly average was 8.1 mph, in August. The highest monthly average was 12 mph, in April. The average 1990 windspeed was 12.1 mph, and the normal wind direction in 1990 at O'Hare airport was from a direction of 235°, or from the southwest. During 7 months of 1990, the winds were from the south-southwest, southwest, or west-southwest.

3.2 POTENTIALLY EXPOSED POPULATIONS

The Lenz Oil site is currently vacant and idle. Access to the site is controlled by a combination of wire, chain-link, and wooden fencing, but there are gaps in the fence in the northern and western corners. During a site visit, a footpath was noted on the western boundary of the site. Land use around the site is a mixture of residential, idle open land, and commercial and light industrial (see Figure 1-2).

Illinois Route 83 parallels the western boundary of the site and is elevated on concrete pilings. Jeans Road parallels the south site boundary. The area to the south of the site is open land (that is, fields, woods, and wetlands) with a few houses. The Williams residence is located directly across Jeans Road to the south. Two residences are located about 600 feet farther south of the site along the Des Plaines River, and a third residence is located approximately 400 feet southwest across Route 83. The Lenz residence is located adjacent to the site to the east. A small pond is located just north of the Lenz house. Abandoned trailer homes and a scrap yard are located east of the site and the pond. Light industrial and commercial properties are located farther to the east along Jeans Road. Two homes are located approximately 250 feet and 750 feet southeast of the site along Jeans Road.

The Atchison, Topeka, and Santa Fe Railroad runs along the north boundary of the site. The area to the northwest beyond the railroad is primarily wooded open land with scattered residential and commercial properties. A bluff rises from the railroad tracks to the northwest, with residences located along the bluff top approximately 750 feet from the site. The area southwest and west of the site is used for commercial purposes (that is, a large auto wrecking facility).

The closest community to the site is Downers Grove, approximately 3,500 feet north of the site along Illinois Route 83, with a population of 46,858. A survey of wells completed for the RI identified 310 residential, commercial, and industrial wells within approximately 2 miles of the site. The Argonne National Laboratory reservation is located approximately 1,400 feet northwest of the site. Several large industrial complexes are located along the Des Plaines River both upstream and downstream of the site.

Discussions of potentially exposed populations in the vicinity of the Lenz Oil site follow in Sections 3.2.1 through 3.2.9. The relationships of potentially exposed populations to exposure pathways is evaluated in Section 3.3. Exposure pathways and exposure point concentrations are discussed in Section 3.3. Chemical intakes are quantified in Section 3.4. Uncertainties within the exposure assessment are discussed in Section 3.5.

3.2.1 On-site Trespassers

On-site trespassers may be exposed to contaminated soils and volatile and particulate air emissions. Trespassers are assumed to be older children (that is, ages 7 to 15) or adults who enter the site infrequently for short periods of time. Since site access is not restricted (a footpath was noted on the site) and scattered residential areas are located near the site, it is assumed that trespassing can occur.

3.2.2 Off-site Populations

Off-site populations may be exposed to contaminants if contaminants migrate offsite. Contaminant migration to off-site soils could result in direct contact exposures, while contaminant migration to air could result in inhalation of volatile and particulate emissions. The closest residences are located adjacent to the site, with additional scattered residences located approximately 250 to 750 feet from the site. The nearest commercial facilities are the auto junkyard and the scrap yard, located approximately 150 feet west and east, respectively, from the site.

Soil exposure risks to off-site receptors are not assessed. Instead, risks to a hypothetical future on-site residential receptor (see Section 3.2.4 below) are evaluated for the soil pathway. Environmental data for soils were collected only at on-site locations, and the contaminants in these soils represent reasonable maximum exposure (RME) conditions for future residents.

The potential migration of contaminants into the air pathway is evaluated in Appendices E and F of this report. Particulate emissions occur when chemicals bind to particles of soil, which are then suspended in air. Organic vapor emissions occur when compounds volatilize into air. RME on-

site particulate emissions are predicted and RME organic vapor emissions are predicted at the site property line of the nearest residence. Based on these evaluations, exposure point concentrations are estimated and risks are evaluated for potential current and future site users.

3.2.3 Future On-site Construction Workers

Future on-site construction workers may be exposed to contaminated soils and volatile and particulate air emissions. It is assumed that the site could be developed in the future for residential use, and that home construction may occur with no site contaminant remediation.

3.2.4 Future On-site Residents

Future on-site residents are included as a potentially exposed population, assuming that the site is developed in the future for residential uses. Exposure to contaminated soil, volatile and particulate air emissions, and contaminated groundwater is assumed.

3.2.5 Surface Water Users

Downgradient surface water users could be exposed to contaminants that may migrate from the site. Technical Memorandum No. 1 of the RI (ERM, 1991a) reported that neither the Metropolitan Water Reclamation District of Chicago or the Illinois State Water Survey were aware of drinking water intakes downstream of the site on the Des Plaines River, the Chicago Sanitary and Ship Canal, or the Illinois and Michigan Canal. The report did identify industries in the area that obtain process water from the Chicago Sanitary and Ship Canal, including the Union Oil refinery at Romeoville and the Commonwealth Edison power plant. These facilities are located directly across the Des Plaines River Valley from the Lenz Oil site. The surface water user pathway is further discussed in Section 3.3.4.

3.2.6 Recreational Surface Water Users

Populations that use downgradient surface waters for recreational uses may be exposed to contaminants that may migrate from the site. Exposure may occur through direct contact with surface water and sediments, or ingestion of surface water during recreational use. Potential recreational uses of the drainage ditch adjacent to the site are limited. Older children (ages 7 to 15) and adults could come in contact with ditch surface waters and sediments during hiking and exploratory activities.

Recreational uses in the Des Plaines River include boating, fishing, and swimming. The recreational pathway for the drainage ditch and the Des Plaines River is further discussed in Section 3.3.5

3.2.7 Fish Consumers

Contaminants transported via groundwater or flow from the drainage ditch into the Des Plaines River may affect area fisheries, resulting in exposure to persons consuming contaminated fish. This pathway is further discussed in Section 3.3.6.

3.2.8 Groundwater Users

Populations in the area that use groundwater for domestic consumption may be exposed to contaminants that migrate from the site. Technical Memorandum No. 1 of the RI (ERM, 1991a) identified groundwater users in the site area through a well survey. Water well records from the Illinois Geological Survey and the Illinois State Water Survey were reviewed, 310 residential, commercial, and industrial wells were identified in the 2-mile radius around the site. The report concluded that all wells northwest of the site are upgradient and that all wells southeast of the site across the Des Plaines River Valley are hydraulically isolated from groundwater flowing beneath the site. Thus, the report concluded that wells potentially impacted by groundwater contamination from the site are confined to those located between the site and the Des Plaines River and a few wells located laterally to the site. Technical Memorandum No. 1 (ERM, 1991a) lists wells that have been identified in the potentially impacted area. These wells were identified either during the well survey, or from a list of wells previously sampled by IEPA. The wells are listed in Table 3-1 of this report.

Municipal water has reportedly been provided to residences in the vicinity of the site during IEPA remedial activities in 1988 (ERM, 1991a). However, at least some residents are using their wells for nonpotable purposes (ERM, 1992b). The Corwin Lenz well located adjacent to the site was sampled during Phase 2 of the RI. The two residences located between the site and the Des Plaines River reportedly use municipal water (PRC, 1992a). No residences are reported to be using area groundwater for potable uses.

3.2.9 Subpopulations of Potential Concern

Subpopulations of potential concern are limited to children who may trespass on the site or children and pregnant women who may be exposed to contaminants that have migrated off site into soil, surface water, sediments, or the air. No schools, day care centers, hospitals, nursing homes, or retirement communities were observed in the site vicinity. Significant commercial and recreational fisheries are not reported in the site area.

TABLE 3-1
LENZ OIL SITE WELLS POTENTIALLY IMPACTED
BY SITE CONTAMINANTS

Well	Location	Depth (ft)
<u>Identified in Remedial Investigation Well Survey</u>		
Dupage County Forest Preserve, Well 83.2	T37N, R11E, Sec. 11 NW 1/4 of NW 1/4 of SW 1/4	200
Corwin Lenz well	T37N, R11E, Sec. 11 SE 1/4 of NW 1/4 of SE 1/4	125
Thomas Redichs well	T37N, R11E, Sec. 11 NE 1/4 of NW 1/4 of SE 1/4	100
Richard Flacs well	T37N, R11E, Sec. 11 SE 1/4 375 Jeans Road	100
Nick Batish well	T37N, R11E, Sec. 11 SE 1/4 of NE 1/4 of SW 1/4 16 W. 115 99th Street	165
<u>IEPA Sampled</u>		
Schuster well	11 S. 305 Jackson Street	unknown
Gruber well	Jeans Road	unknown
Williams Bait Shop Well	Jeans Road	unknown
Kempa well	16W 414 99th Street	unknown
Flacks well	97th Street	unknown
Mason well	Jeans Road	unknown
Stein Haus well	unknown	unknown
Knollwood well	unknown	unknown

Source: ERM, 1991a

3.3 IDENTIFICATION OF EXPOSURE PATHWAYS AND EXPOSURE POINT CONCENTRATIONS

Primary contaminant sources at the Lenz Oil site consist of the ash within the excavated area and the surrounding on-site soils. The conceptual site model (CSM) (Figure 1-5) identifies secondary contaminant sources, potential contaminant transport mechanisms, and potential human and ecological receptors associated with the Lenz Oil site. The CSM also identifies the exposure pathways of potential concern at the site. Each pathway is evaluated further in the exposure assessment to determine if the pathway is complete, that is, if the pathway comes into contact with a receptor. Exposure point concentrations are then identified for complete pathways. The exposure point concentrations should represent areas where the contaminant concentration in contact with a receptor is, or is predicted to be, the greatest.

Exposure pathways are evaluated in the following subsections with exposure point concentrations estimated for complete pathways. Monitoring data are used when available to document a complete exposure pathway and exposure point concentrations. Monitoring data provide an estimate of the current exposure conditions at the site. Exposure point concentrations determined from monitoring data assume that the concentration will remain constant for the exposure period.

A fate and transport analysis and models are used to evaluate exposure pathways in the absence of monitoring data. Models are used when exposure points are spatially separated from monitoring locations (that is, for the air pathway). A fate and transport analysis of groundwater is used to predict if contaminants can migrate to the Des Plaines River in significant concentrations. Incomplete pathways are not carried through the RA.

3.3.1 Soil Exposure Pathways

The CSM identifies complete soil ingestion and dermal contact exposure pathways for site trespassers, future short-term workers, and future residents. The site trespasser pathway (represented in Figure 1-5 as the recreational receptor) is assumed to be complete based on site accessibility, the presence of a footpath on site, and the presence of homes in the area. The future receptor pathways (that is, short-term workers and future residents) are assumed to be complete based on EPA recommendations for choosing the most conservative future land use (EPA, 1989b). Monitoring data are used to estimate the RME exposure point concentration for both the current and future use scenarios. An assumption is made that concentrations will remain constant over time. The RME values for on-site surface soil are documented in Appendix C. Because no samples were taken from the first 6 inches of soil alone, surface soil is defined using samples taken from 0 to 5 feet in depth. As noted in Section 2.4.3, two areas are considered for the soil exposure pathway: the excavated area near the

center of the site, and the surrounding nonexcavated area. Risks to site trespassers, future short-term workers, and future residents are determined for these two areas.

3.3.2 Air Exposure Pathways

The CSM identifies potential pathways for on- and off-site receptors including residents, workers, and site trespassers. As noted earlier, air modeling is performed to predict concentrations of particulate and volatile contaminants. Methods and analyses are summarized in Appendices E and F. On-site concentrations of inorganic and organic contaminants potentially released to the air in fugitive dusts are predicted. Concentrations of organic contaminants released to air through volatilization are predicted at the property line of the nearest residence.

The maximum predicted concentrations of contaminants are used as RME point concentrations for trespassers, future short-term workers, and future residential receptors. Risks via air exposures are assessed for these receptors. The air modeling assumes that no site disturbance is occurring. Particulate and volatile emissions resulting from on-site excavation by future short-term workers would result in higher predicted concentrations of contaminants and higher potential risks. This factor is noted in the discussion of uncertainty.

3.3.3 Groundwater Exposure Pathways

The CSM identifies complete ingestion, dermal contact, and inhalation exposure pathways for groundwater. Ingestion may occur through groundwater consumption, and dermal contact and inhalation exposures may occur through the use of groundwater for washing and showering. The vertical and horizontal extent of the groundwater plume and a layer of nonaqueous phase liquids (NAPLs) was determined in the RI. Groundwater contaminants have been reported to depths of 39 feet, and were generally detected in monitoring wells on site or just off site (that is, less than 100 feet). However, an estimated concentration of 2 part per billion tetrachloroethene was detected in a well approximately 500 feet southeast of the site and 100 feet from the Des Plaines River (ERM, 1991a, 1992a). The migration of groundwater contaminants into the Des Plaines River has not been documented.

A layer of NAPLs is floating on the groundwater beneath the site. The NAPL layer has a thickness of up to 1.91 feet. The lateral extent of the NAPL is not known, but it is not as extensive as the groundwater plume (ERM, 1991a).

As previously noted, municipal water was provided to residences in the vicinity of the site during IEPA remedial activities in 1988 (ERM, 1991a). However, at least some residents are using well

water for nonpotable purposes (ERM, 1992a). RME exposure point concentrations are determined and risks assessed assuming that a future resident in the area or on the site may use groundwater for domestic purposes.

An assumption is made that a hypothetical future resident could drill either a shallow or production well in the aquifer. Because the previous sampling at the site has shown a significant difference in the concentrations of chemicals detected in shallow and deep wells on the site, exposure to estimated shallow and deep ground-water concentrations are evaluated separately. Based on the description of hydrogeological characteristics of the aquifer and the results of slug tests, the horizontal permeability of the aquifer is relatively high. The hydraulic conductivity of the silty gravel facies ranges from 24 to 550 feet per day, and the high value of the hydraulic conductivity of the fractured dolomite is approximately 110 feet per day. Considering a total aquifer thickness of 150 to 200 feet, the shallow aquifer appears to be productive. The aquifer could be developed for domestic wells or even a small community water supply. It may also serve as an agricultural water source for irrigation well development (ERM, 1992a).

As noted in Section 2.4.3, data from wells on site within the groundwater plume (Area A) and data from wells off site and within the groundwater plume (Area B) are grouped separately for the risk assessment. In addition, shallow and deep wells within each area are also grouped separately. The RME values for groundwater ingestion and dermal contact routes are presented in Appendix C. Because of the similarities in chemical concentrations detected in shallow and intermediate depth ground-water samples, these samples were combined to estimate exposure point concentrations. Inhalation exposure point concentrations determined for showering are included in Appendix G.

3.3.4 Surface Water Users Exposure Pathways

The release of ground-water contaminants to the river has not been documented by ground-water monitoring downgradient of the site. An evaluation of the potential impact of detected groundwater contaminants on the Des Plaines River is included in Appendix D. An estimated flow rate of the contaminant plume is compared to a low flow rate of the river. A dilution ratio is determined for the two flow rates. Maximum contaminant concentrations in the groundwater are divided by the dilution ratio to determine hypothetical concentrations in the river at a groundwater-surface interface. The predicted concentrations in the river are then compared to ambient water quality criteria (AWQC) for both humans and aquatic life; these predicted concentrations are below available AWQC benchmarks with the exception of the arochlor isomers 1242 and 1260. AWQC for these contaminants are 0.07 and 0.46 nonograms/liter, respectively, for fish and water consumption by humans. These contaminants were detected in on site ground water, but not in deeper on site or off site wells. This indicates that these compounds may be sorbed to sediments in the shallow ground

water and that they have not migrated beyond on site ground water. Therefore, the risk of exposure to these contaminants from ground-water discharge to surface water was not evaluated in this report. Appendices D and K contain additional details on the dilution ratio analysis and comparisons to AWQC.

No current users of surface water were documented for the Des Plaines River. Based on the groundwater monitoring data, and surface water concentrations predicted via a dilution ratio, the surface water pathway is also considered incomplete for future users. Industrial users of water from the Chicago Sanitary and Ship Canal were documented. Since the Des Plaines River is located between the site and the canal, impacts on canal users are also considered insignificant.

Impacts on the Des Plaines River from the migration of contaminants down the drainage ditch located adjacent to the site are also possible. Site-related contaminants were detected in ditch sediments and to a lesser degree in ditch surface water. The drainage ditch enters the river approximately 1 mile downstream of the site. Since no surface water users are identified for the Des Plaines River, no attempt was made to predict contaminant migration down the ditch into the river. As noted below, risk to potential recreational river users are assessed using contaminant concentrations detected adjacent to the site in the ditch. This is a worst-case scenario, since contaminant concentrations at the ditch-river interface are expected to be less than the concentrations detected adjacent to the site.

3.3.5 Recreation Surface Water Users Exposure Pathways

The CSM identifies potential ingestion and dermal contact exposure pathways for recreational users of the Des Plaines River and the drainage ditch located adjacent to the site. As noted in Section 3.3.4 above, the contaminant concentrations measured in the drainage ditch adjacent to the site are used to determine potential risks to recreational users in the Des Plaines River. These data represent RME concentrations; site-related contaminants transported down the ditch and into the Des Plaines river are expected to be present in lower concentrations.

The ingestion and dermal contact exposure pathways for recreational users along the drainage ditch (for example, children and adults exploring, playing, or hiking in the area) is assumed to be complete because the ditch is accessible and residents are located in the vicinity. RME concentrations for surface water and associated sediments are determined from the available monitoring data. An assumption is made that the contaminants will remain constant over time and that the area sampled is the point where recreational activities could occur. The RME values for surface water and sediments in the ditch are presented in Appendix C.

3.3.6 Fish Consumption Exposure Pathway

The CSM identifies a potential exposure pathway for fish consumption. As noted, the groundwater to surface water pathway analysis in Section 3.3.4 indicates that hypothetical contaminant concentrations in the Des Plaines River are less than AWQC for humans and aquatic life with the exception of the Arochlor isomers 1242 and 1260. These contaminants were detected in shallow on site wells, but not deep on site or off site wells. Because contaminant impacts on the river are not documented, risks to humans from consumption of fish are assumed to be insignificant.

Semivolatile organic contaminants were detected in drainage ditch sediments adjacent to the site. Pyrene was also detected at 2 parts per billion in ditch surface water. The ditch appears to be stagnant at times and is choked at several points with cattails and other plants. The flow rate of the ditch is unknown, but flow direction is to the southwest approximately one mile through an automobile junk yard and a marshy area before discharging into the Des Plaines River. The potential for contaminant migration into fisheries on the Des Plaines River was not quantitatively determined. Semivolatile contaminants in ditch sediments are likely to attenuate. Potential impacts on aquatic receptors are discussed in the ecological assessment for the site.

3.3.7 Summary of Exposure Pathways to be Quantified in This Assessment

Complete exposure pathways and potentially impacted populations are listed below. These pathways will be carried through the quantitative risk assessment. Section 3.4 incorporates exposure point concentrations compiled in Appendix C into equations that estimate chemical intakes for the pathways of concern.

- On-site soils
 - trespasser
 - future short-term worker
 - future resident
- Groundwater
 - future resident
- Air
 - trespasser
 - future short-term worker
 - current and future residents
- Surface water/sediments
 - recreational users

Exposure is defined as the contact of an organism with a chemical or physical agent. The human receptors identified above are assessed quantitatively to determine the magnitude of potential chemical exposures, which is the amount of a chemical available at human exchange boundaries (that is, skin, lungs, gut) during some specific time. A general equation for calculating chemical-specific exposures for populations and exposure pathways is recommended by EPA (1989b). The components of this equation are presented in Section 3.4.2 below. Equations 3-1 and 3-2 calculate intakes that are expressed as the amount of chemical at the human exchange boundary and available for absorption. The calculated intakes are not equivalent to an absorbed dose, which is the amount of a chemical actually absorbed into the bloodstream (EPA, 1989b).

The chemical intake equations determine lifetime average daily intake (LADI) or chronic exposure values. The intake equations can be used to assess lifetime exposures to chemicals with linear non-threshold responses (for example, cancer responses), or to assess long term chronic exposures to noncarcinogens. The exposure values express the repeated and prolonged exposure periods that potentially result in carcinogenic or chronic noncarcinogenic health effects. These exposure periods are assumed for most pathways at the Lenz Oil site, where continuous exposures via air, soil, groundwater, and surface water are assumed. Shorter exposures periods are considered only for future on-site construction workers.

In using the LADI to estimate risk, the upper-bound cancer risk is estimated by multiplying the LADI by a toxicity factor that estimates the cancer potency of a specific chemical. This toxicity factor is determined by the 95-percent confidence limit of the linear slope factor of the dose-response function (that is, the cancer potency factor). Because the slope factor is derived based on an administered dose, exposure is normally expressed as an administered dose rather than an absorbed dose, as noted above. Non-carcinogenic risk is estimated by dividing the chronic exposure intake value by a toxicity factor that estimates the dose at which chronic health effects should not occur. These concepts are discussed further in Section 4.0.

Averaging time variables in equations 3-1 and 3-2 are used to express exposure in a way that makes it comparable to the dose-response relationship. The averaging time value used to determine the LADI is the lifetime over which the exposure is averaged. For carcinogens, this should represent the average life expectancy of the exposed population. An average figure of 70 years is suggested for the lifetime of men and women (EPA, 1991a). For chronic noncarcinogenic effects, the averaging time is the actual period of exposure to the contaminants. A period of 30 years for maximum case exposures is assumed for residential receptors (EPA, 1991a).

A body weight variable in Equations 3-1 and 3-2 is used to calculate total exposure and should reflect the average weight of the exposed population during the time over which exposure occurs. If the exposure occurs continuously throughout an individual's life or only during the adult stages, using an adult average weight of 70 kilograms (kg) provides sufficient accuracy. However, when specific exposure conditions exist for a child, a corresponding body weight (15 kg for children ages 0 to 6) is used (EPA, 1991a).

The standard exposure equations are adapted to each pathway of concern in the following subsections. Section 3.4.1 identifies standard exposure parameters that are applicable for all pathways. Section 3.4.2 introduces exposure estimation methods. Pathway-specific parameters and exposures are identified in Section 3.4.3. Exposure parameters represent upper-bound (that is, 90 or 95th percentile or maximum values) estimates of exposure conditions within each pathway. The reference for each value is presented. Standard EPA default exposure assumptions and reference documents are used for each pathway.

The exposure conditions assume no-action at the site. This no-action alternative means that no capping, removal, or remediation will take place. As described in Section 3.2, both current and future exposures are considered in the risk assessment. Current exposures address existing on- or off-site population receptors. Future exposures assume the future development of the Lenz Oil site, resulting in unrestricted public access and full use of local resources by persons living on the site. The assessment of current and future conditions is intended to reflect the range of significant exposures that could occur under the no-action alternative for site remediation.

3.4.1 Standard Exposure Parameter Assumptions

Standard assumptions were used to estimate chemical intakes for each route of exposure. These assumptions are as follows:

- Exposure is averaged over a 70-year lifetime for cancer risk estimates (EPA, 1991a).
- Exposure duration for noncarcinogenic adverse effects is assumed to be 30 years (national upper-bound time at one residence) for reasonable worst-case scenarios (EPA, 1991a).
- Contact rates for exposure to chemicals in soils are 200 mg soil/day for children and 100 mg/day for adults for the ingestion route (EPA, 1991a), and 1.0 mg/cm² for the dermal absorption route (EPA, 1992a).
- The daily drinking water ingestion rate for exposure to chemicals in ground water is 2 L/day for adults and 1 L/day for children (EPA, 1990a and 1991a).

- The daily contact rate for exposure to chemicals in air is 20 m³/day for inhalation for residential exposure on site (EPA, 1991a).
- The average lifetime body weight for the exposed population is 70 kg (EPA, 1991a).
- The average body weight for 1- to 6-year-old children is 15 kg (EPA, 1991a).

The pathway-specific discussions in Section 3.4.3 describe these assumptions in more detail and identify pathway-specific assumptions.

3.4.2 Exposure Estimation Methods

The foregoing assumptions were used in combination with site-specific data to estimate a range of chemical exposures that could be used in the risk characterization. The RME were calculated based on the upper 95 percent confidence limits of mean concentrations and 95th or 90th or maximum percentile values for contact rate, exposure frequency, and exposure duration when data were available (EPA, 1989b).

In each case, a different expression was used to estimate exposure for carcinogenic and noncarcinogenic effects. For cancer risk assessments, exposure is averaged over body weight and lifetime as follows:

$$\text{LADI} = \frac{\text{Total Exposure}}{\text{Body Weight} \times \text{Lifetime}} \quad (3-1)$$

For noncarcinogenic effects, exposure is averaged over body weight and the time over which exposure actually occurs:

$$\text{Chronic exposure} = \frac{\text{Total Exposure}}{\text{Body Weight} \times \text{Averaging Time}} \quad (3-2)$$

Total exposure can be expanded as follows (EPA, 1990a):

$$\text{Total exposure} = \text{Contaminant Concentration} \times \text{Contact Rate} \times \text{Exposure Duration} \quad (3-3)$$

Contaminant concentration is the concentration of the contaminant in the medium (air, water, soil, etc.) contacting the body. These concentrations are defined as exposure point concentrations, and are discussed and identified in Sections 2.6 and 3.3 of this report.

The contact rate refers to the rate of inhalation, ingestion, or dermal contact. For example, the ingestion contact rate is simply the amount of water or soil containing the contaminant of interest that an individual ingests during some specific period.

The exposure duration is the length of time over which the receptor comes into contact with the contaminant. Factors such as the length of time a person lives in an area and time spent indoors vs. outdoors affect the exposure duration. When these parameter levels remain constant over time, they are substituted directly into the exposure equation. When they change with time, a summation approach is needed to calculate exposure. In either case, the exposure duration is the length of time exposure occurs at the concentration and contact rate specified by the other parameters in the equation.

Exposure to contaminants can be expressed as a total amount, an exposure rate, or as a rate normalized to body mass. Exposure estimates derived as a rate normalized to body mass are summarized in Section 3.4.3 for each exposure pathway.

3.4.3 Exposure Scenarios

Scenario 1: Direct ingestion of on-site surface soils

Future short-term workers, future residents, and site trespassers are the potentially exposed populations in this exposure pathway. It is assumed that a short-term worker incidentally ingests some amount of contaminated soil during each work day. For certain outdoor activities in a commercial and industrial setting (for example, construction or landscaping), a soil ingestion rate of 480 mg/day may be anticipated (EPA, 1991a). This is representative of the short-term construction worker scenario. It is assumed that construction activities will have a duration of 10 weeks, with an 8-hour a day, 5-day week exposure frequency, resulting in a total exposure time of 50 days. This exposure duration is derived from the assumption that one house per one-fourth acre can be constructed on the 5-acre site, for a total of 20 houses. Two and one-half days of exposure per house are assumed for construction workers who lay underground piping (that is, gas, water, sewer) and assist in site cleanup after backfilling each lot.

The future residential scenario assumes that the site is developed for residential use and that the soil exposure pathway is present. Children play in soil near their homes and are presumed to ingest soil as a result of sucking thumbs, fingers, toys, candy, or other objects that may be contaminated with soil from the site. Adults may incidentally ingest soil primarily during outdoor activities such as gardening. The tracking of soil into the home and subsequent ingestion of indoor dust is also assumed.

Soil ingestion rates can vary enormously from 10 mg/day to 10,000 mg/day for 1.5- to 3.5-year-old children (EPA, 1990a). In general, 1- to 6-year-old children have a relatively high soil ingestion rate, which is largely attributed to their patterns of outdoor play and high hand-to-mouth activity. However, these rates must be amortized over 70 years to assess lifetime cancer risks. As noted in Section 3.4.1, an average ingestion rate of 200 mg soil/day for children age 0 to 6 and 100 mg/day for others is assumed for each day of exposure (EPA, 1990a, 1991a).

The residential scenario assumes that a child would be exposed to soil or dust 350 days per year for 6 years (ages 0 to 6), or approximately 2,100 days over a lifetime (EPA, 1991a). An adult would be exposed for 350 days per year for 24 years, or approximately 8,400 days (EPA, 1991a). This represents a 30-year exposure period, the 90th percentile for living at one residence in the United States (EPA, 1989b). The assumption is made that soil ingestion would still occur via dusts inside the home originating from the site on those days when outside exposure is limited.

The on-site trespasser scenario assumes that older children ages 7 to 15 and adults can ingest soils during activities on the site. A soil ingestion rate of 100 mg soil/per day is assumed for these age groups (EPA, 1991a). An average body weight for the older children age group is determined by taking the average of mean body weights for male and female children in the following age group series: 6 to 9 years, 9 to 12 years, and 12 to 15 years. This average body weight is 37 kilograms (EPA, 1990a).

An assumption is made that a trespasser may stay on site over 1 hour, for a total of 10 times per year. One hour is the chosen duration because there is no evidence that longer term trespassing may take place on the site (for example, sporting activities). One hour was arbitrarily chosen as the length of time a trespasser may take to pass across and explore the site.

The trespasser scenario assumes that an older child could be exposed to soil or dust over a period of 9 years (ages 7 to 15) and that an adult could be exposed for a period of 21 years. This represents a total of 30 year of exposure for the two groups, the 90th percentile for living at one residence in the United States (EPA, 1989b).

To calculate the LADI resulting from incidental ingestion of on-site soils containing carcinogens, the following equation is used:

$$LADI = \frac{(CR) (C) (EF) (ED) (0.001 \text{ kg/g})}{(BW) (LT) (365 \text{ days/yr})} \quad (3-4)$$

where:

- CR = soil consumption rate (0.2 g/day for a child and 0.1 g/day for a resident adult, 0.480 g/day for a future on-site worker, 0.1 g/day for an on-site trespasser if assessed)
- C = concentration of contaminant in soil (chemical specific, mg/kg)
- EF = exposure frequency (1 hour/event and 10 events/year for trespasser)
- ED = exposure duration (6 years and 24 years for resident children and adults respectively; 50 days for future on-site workers; 9 years and 21 years for trespassing older children and adults respectively. Note: all exposure durations expressed in years must be converted to days by multiplying by 365 days/ year.)
- BW = body weight (15 kg for children age 0 to 6, 37 kg for children age 7 to 15, 70 kg for adults)
- LT = lifetime (70 yr)

For calculating exposure resulting from incidental ingestion of on-site soil to evaluate noncarcinogenic effects, the following equation is used:

$$\text{Chronic exposure} = \frac{(CR) (C) (ED) (0.001 \text{ kg/g})}{(BW) (AT)} \quad (3-5)$$

where:

- AT = averaging time, (30 years for chronic exposures, 50 days for future short-term workers. Note: all averaging times expressed as years must be converted to days by multiplying by 365 days/ year.)

Other factors are the same as in the equation for carcinogens.

Scenario 2: Dermal contact with soils

Future short-term workers, future residents, and on-site trespassers are the potentially exposed populations in this exposure pathway. The following exposure parameters are specific to the direct contact route: surface area available for contact, soil-to-skin adherence factors, and absorption factors.

Future on-site workers may be exposed to soil contaminants by dermal contact with soil and dust during construction activities. Dermal exposure may occur on the hands, legs, arms, neck, and head. A conservative assumption is made that 25 percent of the total body surface area is available for exposure (EPA, 1992a). The default value for the 50th percentile total adult body surface area

is 20,000 cm², resulting in an available surface area of 5,000 cm² for future workers (EPA, 1992a). The assumed exposure duration is the same time period as that for soil ingestion (that is, 50 days). Exposure frequency is assumed to be 1 event per day.

The future residential scenario assumes that the site is developed for residential use and that the soil exposure pathways is present. Children will be exposed to contaminated soil through outdoor recreational activities and indoor dust. The amount of skin exposed during play is assumed to vary with the seasons: 25 percent for the summer, 10 percent for fall and spring, and 5 percent for winter (EPA, 1990a, 1992a). The total body surface area for children is determined from the average of 50th percentile values for male and female children ages 5 to 6, and equals 7,860 cm² (EPA, 1990a). The fractions of total surface area available during each season are calculated and then averaged to determine the seasonal average skin surface area exposed of 1,048 cm².

Adults living on site are also assumed to be exposed via dermal contact with contaminated soils. The seasonally adjusted average skin surface area exposed is also determined for adults following the method outlined above for children. The total surface area default value of 20,000 cm² is assumed for adults (EPA, 1992a). Seasonal fractions are then calculated and averaged to determine an adult seasonal average skin surface area exposed of 2,666 cm².

Exposure frequency for both adults and children is assumed to be 1 event/day for 350 days/year, equaling 350 events/year. This estimate is based on contact that may occur from recreation and gardening, and from exposure to contaminated dusts in the home. Two age groups are considered: children age 0 to 6, and all others. Exposure duration is assumed to be 30 years (that is, 6 years for children and 24 years for others (EPA, 1989b).

The amount of soil that adheres to exposed skin is another parameter necessary for calculating exposure. Reported studies identify a range of possible soil adherence values, all with associated uncertainties. A soil adherence rate of 1.0 mg/cm² of skin is assumed as a reasonable upper value (EPA, 1992a).

Absorption factors (ABS) are used to reflect desorption of the chemical from soil and the absorption of the chemical across the skin and into the blood stream per exposure event. Since chemical-specific absorption factors for site contaminants are not available in EPA documentation (EPA, 1992a), ranges of absorption factors are estimated for the three major chemical classes. These values are based on the available toxicology data and reflect the contaminant's physical and chemical properties. For volatile organic compounds, the absorption factors range from 10 to 25 percent, for semi-volatile organic compounds, including pesticides, the absorption factors range from 1 to 10 percent, and for inorganic compounds, the absorption factors range from 0.1 to 1 percent (Ryan and

others, 1987). These ranges provide a means for more accurately estimating direct contact exposure with soils. The maximum absorption factors were used for this assessment.

For the on-site trespasser scenario, the above-mentioned exposure parameters are assumed, with the following exceptions:

- Older children (ages 7 to 15) are assumed because this group is more likely than younger children to play and explore outside of their own residential areas.
- Ages 16 and older are grouped into the adult category.
- Total body surface area for older children is determined from the average of 50th percentile values for male and female in nine age group series ranging from 6 to 7 to 14 to 15 years.
- The average of 50th percentile values for these age groups is 11,900 cm² (EPA, 1992a).
- Exposure is assumed to occur in the summer months; for older children, 25 percent of the total surface area (or 2,975 cm²) is assumed to be exposed (EPA, 1992a). For adults, 25 percent of 20,000 cm² (or 5,000 cm²) is assumed.

The body weight for older children is assumed to be 37 kg as discussed in the soil ingestion scenario above. The exposure time, frequency, and duration for the trespasser is also discussed in the soil ingestion scenario above.

To calculate LADI resulting from dermal contact with soil, the following equation is used for carcinogens:

$$\text{LADI (mg/kg/d)} = \frac{(C) (CF) (SA) (AF) (ABS) (EF) (ED)}{(BW) (LT)} \quad (3-6)$$

where:

- C = contaminant concentration in soil (chemical-specific, mg/kg)
- CF = used to convert to mg/kg/d
- SA = surface area available for contact (1,048 cm² and 2,666 cm² for child and adult residents, 5,000 cm² for workers, 2,975 cm² for older children, and 5,000 cm² for adult trespassers)
- AF = soil-to-skin adherence factor (1.0 mg/cm²)
- ABS = absorption factor (percent of chemical in soil absorbed/event)
chemical-specific from Appendix G or
0.25 for volatiles
0.10 for semi-volatiles and pesticides
0.01 for inorganics

- EF = exposure frequency (50 events/year for on-site worker, 350 events/year for on-site residences, and 10 events/year for trespassers)
- ED = exposure duration (6 years for child residents, 24 years for adult residents, 9 years for older child trespassers, 21 years for adult trespassers, 50 days for on-site workers)
- BW = body weight (15 kg for children age 0 to 6, 37 kg for children age 7 to 15, 70 kg for adults)
- LT = lifetime (70 yr)

For noncarcinogens, the following equation is used to calculate exposure resulting from dermal contact with soil:

$$\text{Chronic exposure (mg/kg/d)} = \frac{(C) (CF) (SA) (AF) (ABS) (EF) (ED)}{(BW) (AT)} \quad (3-7)$$

where:

AT = averaging time (30 years for chronic exposures, 50 days for future short-term workers).

All other factors are the same as in the equation for carcinogens.

Scenario 3: Particulate and Volatile Inhalation

In this scenario, on- or off-site human receptors are potentially affected by volatile and particulate air emissions from the site. Exposure point concentrations are determined for the site area and the property line of the nearest residence. Estimated particulate emissions are assumed to be in the respirable range (i.e., <10, μm). It is also assumed that 100 percent of the particles inhaled are retained in the lung.

On-site workers are assumed to be exposed for 8 hours a day, 5 days a week, over a 10-week period, as described in the soil ingestion scenario above. The inhalation rate for workers is assumed to be $3.0 \text{ m}^3/\text{hour}$. This represents a reasonable worst-case outdoor inhalation rate for an adult highly active for 50 percent of the time and moderately activity for 50 percent of the time (EPA, 1990a).

Potential on-site residents are assumed to be exposed to indoor and outdoor dusts and vapor concentrations 24 hours/day, 350 days/year for 30 years (EPA, 1991). The reasonable upper-bound daily inhalation rate of $20 \text{ m}^3/\text{day}$ (or $0.83 \text{ m}^3/\text{hr}$) is assumed for adult residents (EPA, 1991).

For on-site trespassers, the age groups, body weights, exposure time, and exposure frequency identified in the soil ingestion scenario above are assumed. The hourly inhalation rate is assumed to be the same as for adult residents, 0.83 m³/hr.

To calculate LADI for volatile and particulate contaminants the following equation is used for carcinogens:

$$\text{LADI} = \frac{(\text{IR}) (\text{CF}) (\text{C}) (\text{EF}) (\text{ED})}{(\text{BW}) (\text{LT})} \quad (3-8)$$

where:

- IR = inhalation rate (3 m³/hour for workers; 20 m³/day for residents; 0.83m³/hour for trespassers)
- CF = used to convert to mg/kg/d
- C = chemical concentration in air (chemical-specific, mg/m³)
- EF = exposure frequency (8 hours/day for 50 days/year for on-site workers, 24 hours/day for 350 days/year for residents, and 1 hour/day for 10 days/year for trespassers)
- ED = exposure duration (30 years for residents, 50 days for future on-site workers, 9 years for older children and 21 years for adults. Note: ED expressed in years must be converted to days by multiplying by 365 days/year)
- BW = body weight (15 kg for children age 0 to 6, 37 kg for children age 7 to 15, 70 kg for adults)
- LT = lifetime (70 years).

For noncarcinogens, the following equation is used to calculate exposures resulting from inhalation of particulate or volatile contaminants:

$$\text{Chronic exposure} = \frac{(\text{IR}) (\text{CF}) (\text{C}) (\text{EF}) (\text{ED})}{(\text{BW}) (\text{AT})} \quad (3-9)$$

where:

- AT = averaging time (30 years for chronic exposures, 50 days for future short-term workers).

The other factors are as defined in the equation for carcinogens.

Scenario 4: Ingestion of Contaminated Groundwater

Ingestion of contaminated groundwater in the site area is considered for future residents, assuming that the site can be developed for residential use and a well can be installed to draw from the contaminated aquifer. A default value of 2.0 liters of water consumed per day from the contaminated aquifer is assumed for potential residential exposure. This value is close to the 90th percentile for drinking water ingestion and is comparable to the eight glasses of water per day historically recommended by health authorities (EPA, 1991a). A default value of 1.0 liter of water consumed per day is assumed for children (EPA, 1990a). It was further assumed that the exposure duration would be for 350 days a year, with 6 years of exposure for children ages 0 to 6 and 24 years of exposure for adults (EPA, 1991a). This represents a 30-year exposure period, the 90th percentile for living at one residence in the United States (EPA, 1989b).

The LADI for ingestion of carcinogenic chemicals in groundwater is calculated as follows:

$$\text{LADI} = \frac{(\text{CR})(\text{CF})(\text{C})(\text{ED})}{(\text{BW})(\text{LT})(365 \text{ days/yr})} \quad (3-10)$$

where:

- CR = water consumption rate (2 L/day for adults and 1 L/day for children)
- CF = used to convert to mg/kg/d
- C = concentration of contaminant in water (chemical-specific, mg/L)
- ED = exposure duration (6 years for children, 24 years for adults)
- BW = body weight (15 kgs for children and 70 kg for adults)
- LT = lifetime (70 yr)

Exposure estimates for the noncarcinogenic effects of contaminants were calculated using the following equation:

$$\text{Chronic exposure} = \frac{(\text{CR})(\text{CF})(\text{C})(\text{ED})}{(\text{BW})(\text{AT})} \quad (3-11)$$

where:

- AT = averaging time (30 years)

The other factors are as defined in the equation for carcinogenic effects of contaminants.

Scenario 5: Dermal Contact with Contaminated Groundwater

Scenario 5, like scenario 4, assumes that the groundwater is currently being used by area residents, or that future residential use of groundwater could occur. Dermal exposure may occur during

showering or bathing. The following exposure parameters are specific to the direct contact route: surface area available for contact, dermal permeability factors, and exposure frequency.

Whole body exposure is assumed for children and adults for bathing and showering. The total body surface area for children is determined from the average of 50th percentile values for male and female children ages 5 to 6, and equals 7,860 cm² (EPA, 1990a). The total surface area default value of 20,000 cm² is assumed for adults (EPA, 1992a). The exposure time for bathing or showering is assumed to be 15 minutes per day (EPA, 1992a). Exposure frequency is assumed to be 350 days per year, and the number of years of exposure assumed is 6 years for children and 24 years for adults.

Dermal permeability factors estimate the potential for transport of a chemical across the skin barrier into the blood stream. Chemical-specific factors are used if available in EPA documentation (EPA, 1992a) (see Appendix I). Otherwise, the permeability factor for water, 8.4 x 10⁻⁴ cm/hr, is used (EPA, 1989b).

The equation for calculating LADI to carcinogens in groundwater from direct contact while showering is as follows:

$$\text{LADI} = \frac{(C) (SA) (PC) (ET) (EF) (ED) (CF)}{(BW) (LT)} \quad (3-12)$$

(mg/kg/d)

where:

- C = contaminant concentration in ground water (chemical-specific, mg/L)
- SA = surface area of skin contacted (7,860 cm² for children, 20,000 cm² for adults)
- PC = permeability factor (chemical-specific, or for water (8.4 x 10⁻⁴ cm/hr)
- ET = exposure time (0.25 hr/day)
- EF = exposure frequency (350 days/year)
- ED = exposure duration (6 years for children, 24 years for adults)
- BW = body weight (15 kg for children, 70 kg for adults)
- LT = lifetime (70 yr)
- CF = used to convert to mg/kg/d

For evaluating noncarcinogenic effects, the following equation is used to calculate exposure resulting from dermal contact with groundwater while showering:

$$\text{Chronic exposure} = \frac{(C) (SA) (PC) (ET) (EF) (ED) (CF)}{(BW) (AT)} \quad (3-13)$$

(mg/kg/d)

where:

AT = averaging time (30 years)

All other factors are the same as in the equation for carcinogens.

The resulting exposures are expressed as absorbed dose rather than administered doses (e.g., intake). This is because permeability factors reflect movement of the chemical across the skin into the blood stream, resulting in an absorbed dose treatment. EPA (1989b) recommends that adjustments be made to match the dermal exposure estimates (expressed as absorbed dose) with the toxicity values (expressed as administered dose). These adjustments were not made in the RA, the resulting uncertainty is discussed in Section 3.5.

Scenario 6: Inhalation of Groundwater Contaminants

Scenario 6, like scenario 4, assumes that the groundwater is currently being used by area residents, or that future residential groundwater use could occur. Inhalation exposures may occur during showering because of the volatilization of organic compounds.

Air concentrations estimates of organic compounds are contained in Appendix G. A default inhalation rate of $0.6 \text{ m}^3/\text{hr}$ is assumed (EPA, 1990a). An exposure frequency of 15 minutes per shower, one shower per day, over 350 days each year is assumed (EPA, 1992a). Exposure duration is assumed to be 30 years (EPA, 1991a).

To calculate LADI to groundwater contaminants via showering, the following equation is used for carcinogens:

$$\text{LADI} = \frac{(\text{IR})(\text{CF})(\text{C})(\text{EF})(\text{ED})}{(\text{BW})(\text{LT})} \quad (3-14)$$

where:

IR = inhalation rate ($0.6 \text{ m}^3/\text{hr}$)

CF = used to convert to $\text{mg}/\text{kg}/\text{d}$

C = Predicted concentrations (ug/m^3)

EF = exposure frequency (15 minute/shower)

ED = exposure duration (30 years or 10,500 days)

BW = body weight of average adult (70 kg)

LT = lifetime (70 years).

For calculating exposure through inhalation of contaminants in groundwater during showering, the following equation is used for noncarcinogens:

$$\text{Chronic exposure}_i = \frac{(\text{IR})(\text{CF})(\text{C})(\text{EF})(\text{ED})}{(\text{BW})(\text{AT})} \quad (3-15)$$

where:

AT = averaging time (30 years)

The other factors are as defined in the equation for carcinogens.

Scenario 7: Dermal Contact with Surface Water

Soil contaminants may migrate off the Lenz Oil site with surface water that collects in the drainage ditch running along the north side of the site, or with groundwater that discharges from the site area into the Des Plaines River. Samples were taken of surface water and sediments in the drainage ditch adjacent to the site. No samples were taken in the Des Plaines River. As noted in Sections 3.3.4 and 3.3.5, groundwater impacts on the Des Plaines River appear to be insignificant.

It is assumed that children and adults may be exposed to surface water contaminants from the site during recreational activities such as swimming, wading, and fishing. Migration of contaminants through the drainage ditch to the Des Plaines River is not evaluated. Instead, risks to potential receptors in the river are determined from the environmental data relating to drainage ditch water and sediments. An assumption is made that the contaminant levels present in the ditch adjacent to the site represent reasonable maximum exposure conditions and that contaminants transported down the ditch and out into the Des Plaines River would be present in lower concentrations.

Two exposure scenarios are thus considered. Whole body exposures that are likely to occur during recreational activities in the river are assessed, using the drainage ditch environmental data. Partial body exposures are also assessed, which represent exposure conditions that could occur during recreational activities in the drainage ditch.

For the Des Plaines River scenario, whole body exposure is assumed (i.e. swimming). Older children ages (7 to 15) are assumed for this scenario because these ages are more likely than younger children to play and explore outside of their own residential areas and to swim in the river. Ages 16 and older are grouped into the adult category. Total body surface area for older children is determined from the average of 50th percentile values for males and females in nine age group series ranging from 6 to 7 through 14 to 15. The average of 50th percentile values for these age groups is 11,900 cm² (EPA, 1992a). The total surface area default value of 20,000 cm² is assumed for adults (EPA, 1992a).

For the drainage ditch scenario, partial body exposure is assumed (that is, wading). For children ages 7 to 15, exposure to legs and feet is assumed. EPA (1990a) lists leg and feet percent values of total body surface area. The percent values are averaged for the age group categories between 6 and 15 that have available data (that is, ages 6 to 7, 9 to 10, 12 to 13, and 14 to 15). The average percent value is 37 percent. Thirty-seven percent of the total body surface area determined above (that is, 11,900 cm²) is assumed for partial body exposure (that is, 4,403 cm²). For adults, exposure to lower legs and feet is assumed. EPA (1992a) lists lower leg and feet surface areas for male and female adults. The average surface area for male and female legs and feet is assumed (that is, 3,050 cm²).

The default value listed in EPA documentation (1992a) for the time and frequency spent swimming is assumed (that is, 0.5 hour/event, with a frequency of 1 event/day and 5 days/year). The number of years of exposure assumed is 9 years for older children and 21 years for adults. This represents a total of 30 year of exposure for the two groups, the 90th percentile for living at one residence in the United States (EPA, 1989b). The body weight assumed for older children (37 kg) is discussed earlier in the soil ingestion scenario.

As noted for the dermal contact with groundwater scenario, permeability factors are used if available in EPA documentation (1992a) (see Appendix I). Otherwise, a default value for water of 8.4×10^{-4} cm/hour is used (EPA, 1989b).

The equation for calculating LADI to carcinogens in surface water from direct contact is:

$$\text{LADI} = \frac{(\text{C})(\text{SA})(\text{PC})(\text{ET})(\text{EF})(\text{ED})(\text{CF})}{(\text{mg/kg/d})(\text{BW})(\text{LT})} \quad (3-16)$$

where:

- C = contaminant concentration in surface water (chemical specific, mg/L)
- SA = surface area of skin contacted (For Des Plaines River scenario, 11,900 cm² for older children, 20,000 cm² for adults. For the drainage ditch scenario, 4,403 cm² for older children, 3,050 cm² for adults)
- PC = dermal permeability constant (chemical-specific, or for water (8.4×10^{-4} cm/hr)
- ET = exposure time (0.5 hr/day)
- EF = exposure frequency (5 days/year)
- ED = exposure duration (9 years for older children, 30 years for adults)
- CF = used to convert to mg/kg/d
- BW = body weight (37 kg for older children, 70 kg for adults)

LT = lifetime (70 yr)

For evaluating noncarcinogenic effects, the following equation is used to calculate exposure resulting from dermal contact with surface water while swimming:

$$\text{Chronic exposure} = \frac{(C) (SA) (PC) (ET) (EF) (ED) (CF)}{(BW) (AT)} \quad (3-17)$$

(mg/kg/d)

where:

AT = averaging time (30 years)

All other factors are the same as in the equation for carcinogens.

The resulting exposures are expressed as absorbed dose rather than administered doses (e.g., intake). This is because permeability factors reflect movement of the chemical across the skin into the blood stream, resulting in an absorbed dose treatment. EPA (1989b) recommends that adjustments be made to match the dermal exposure estimates (expressed as absorbed dose) with the toxicity values (expressed as administered dose). These adjustments were not made in the RA; the resulting uncertainty is discussed in Section 3.5.

Scenario 8: Incidental Ingestion of Surface Water

Incidental ingestion of surface water may occur when persons are swimming or accidentally fall into the Des Plaines River during recreational activities. As noted in the dermal-contact-with-surface-water scenario, risks to Des Plaines River recreational users are determined using the drainage ditch analytical data.

The default value of 50 mL/hour recommended in EPA documentation (1989b) for surface water ingestion while swimming is assumed to be consumed unintentionally. The age categories, frequency and duration of exposure, and body weights are assumed to be the same as those for the dermal contact-with-surface-water scenario.

The LADI from carcinogens incidentally ingested in surface water is as follows:

$$\text{LADI} = \frac{(C) (CR) (ET) (EF) (ED) (CF)}{(BW) (LT)} \quad (3-18)$$

(mg/kg/d)

where:

C = contaminant concentration in surface water (chemical-specific, mg/L)

CR = contact rate (0.05 L/hr)

- ET = exposure time (0.5 hr/event)
- EF = exposure frequency (5 days/year)
- ED = exposure duration (9 years for older child, and 30 years for adult)
- CF = used to convert to mg/kg/d
- BW = body weight (37 kg for a child, 70 kg for an adult)
- LT = lifetime (70 yr)

For evaluating noncarcinogenic effects, the following equation is used to calculate exposure resulting from incidental ingestion of surface water:

$$\text{Chronic Exposures (mg/kg/d)} = \frac{(C) (CR) (ET) (EF) (ED) (CF)}{(BW) (AT)} \quad (3-19)$$

where:

AT = averaging time (30 years)

All other factors are the same as in the equation for carcinogens.

Scenario 9: Dermal Contact with Sediments

Contaminated sediments could also be contacted by children and adults during recreational activities. The older children (ages 7 to 15) and adult age groups considered in the surface water pathway assessment are assumed. Older children are assumed to wade barefoot and explore with their hands in sediments. For older children, exposure to hands and feet is assumed. EPA (1990a) lists hands and feet percent values of total body surface area. The percent values are averaged for the age group categories between 6 and 15 that have available data (that is, ages 6 to 7, 9 to 10, 12 to 13, and 14 to 15). The average percent value is 12.5 percent. Twelve-and-one-half percent of the total body surface area determined for this age group (that is, 11,900 cm²) is assumed for exposure to sediments (that is, 1,487 cm²). For adults, exposure is assumed to feet only. EPA (1992a) lists feet surface areas for male and female adults. The average surface area for male and female feet is assumed (that is, 1,047 cm²).

Exposures in the drainage ditch and in the Des Plaines River are considered. As noted in the surface-water-exposure-pathways scenarios, environmental data relating to the drainage ditch are used to assess both scenarios. Exposure frequency and duration are considered to be the same as for the surface water dermal contact scenario described above. Absorption factors and adherence factors

for chemicals in sediments are assumed to be the same as those used in the dermal-contact-with-soils scenario described earlier.

To calculate LADI resulting from dermal contact with sediments, the following equation is used for carcinogens:

$$\text{where: } \text{LADI} = \frac{(C) (CF) (SA) (AF) (ABS) (ET) (EF) (ED)}{(\text{mg/kg/d}) (BW) (LT)} \quad (3-20)$$

- C = contaminant concentration in sediments (chemical-specific, mg/kg)
- CF = used to convert to mg/kg/mg
- SA = surface area available for contact (1,487 cm² for older children, 1,047 cm² for adults)
- AF = soil to skin adherence factor (1.0 mg/cm²)
- ABS = absorption factor (percent of chemical absorbed from sediment/event)
0.25 for volatiles
0.10 for semi-volatiles and pesticides
0.01 for inorganics
- EF = exposure frequency (5 events/year)
- ED = exposure duration (9 years for older children, 21 years for adults)
- BW = body weight (37 kg for older children, 70 kg for adults)
- LT = lifetime (70 yr)

For evaluating noncarcinogenic effects, the following equation is used to calculate exposure resulting from dermal contact with sediments:

$$\text{Chronic Exposure} = \frac{(C) (CF) (SA) (AF) (ABS) (ET) (EF) (ED)}{(\text{mg/kg/d}) (BW) (AT)} \quad (3-21)$$

where:

- AT = averaging time (30 years)

All other factors are the same as in the equation for carcinogens.

3.5 UNCERTAINTIES IN EXPOSURE ASSESSMENT

The exposure estimation methods described in Section 3.4 are subject to varying degrees of uncertainty. Uncertainty is inherent in the selection of exposure pathways and in the parameters used to estimate exposure doses. The degree of uncertainty generally depends on the amount of

site-specific data available. This section identifies the most significant areas of uncertainty for the Lenz Oil site exposure assessment and assesses the potential impact of this uncertainty.

The following sources of uncertainty are discussed below and are summarized in Table 3-2:

- Exposure pathway identification, with the assumption of RME future land uses
- Exposure parameters and assumptions
- Assumption of steady-state conditions
- Environmental chemical characterization
- Modeling procedures

3.5.1 Exposure Pathway Identification

The exposure pathways for this risk assessment were identified based on the observed and assumed activities of the local population. To the degree that actual activity patterns are misrepresented, uncertainty is introduced into the risk assessment.

In general, current activity patterns can be estimated with a good degree of accuracy. To a somewhat lesser degree, can the activity patterns of future homeowners and on-site workers be estimated based on existing site conditions. Therefore, all exposure estimates developed under future land use scenarios must be considered in light of the uncertainties of both future activity patterns and future land uses. Exposure doses based on future land uses may overestimate the actual exposure doses.

3.5.2 Exposure Parameters and Assumptions

Standard assumptions for population characteristics, such as body weight, surface area, life expectancy, and period of exposure; and exposure characteristics, such as frequency, duration, amount of intake or contact, and degree of absorption or soil adherence, may not accurately represent exposure conditions. The effect of population characteristic differences (which may overestimate or underestimate actual exposures) will probably be small when considering the entire potentially exposed population because the population characteristics used in the RA are based on national averages or large sample populations. However, these characteristics may not accurately represent individuals who are exposed. For example, residents may spend their entire lives at one residence on or near the Lenz Oil site rather than the 30-year national upperbound time.

TABLE 3-2
AREAS OF EXPOSURE ASSESSMENT UNCERTAINTY
AND EFFECTS ON EXPOSURE ESTIMATES

<u>Area of Uncertainty</u>	<u>May Overestimate Exposure</u>	<u>May Underestimate Exposure</u>	<u>May Over-or Underestimate Exposure</u>
<u>Exposure Pathways</u>			
The assumption of future residential land use on site	X		
Fugitive dusts resulting from site excavation not evaluated for future short-term worker		X	
<u>Exposure Parameters and Assumptions</u>			
Assumptions regarding population characteristics such as body weight, surface area, and life expectancy, activity patterns, and exposure characteristics such as frequency, duration, and amount of intake may not be representative of actual exposure conditions.			X
<u>Steady-State Conditions</u>			
Chemical concentrations measured in or estimated from the RI are assumed to remain constant and represent current and future environmental conditions.	X		
<u>Environmental Chemical Characterization</u>			
Potential seasonal variations ignored.			X
Nonrandom sample collection.	X		
Assumption of uniform concentrations.			X
Replacement of ND results with a value equal to one-half the sample detection limit.			X
Comparison to background concentrations.	X		X
Use of unfiltered versus filtered results.			
<u>Air Modeling Procedures</u>			
Potential transformation processes are not evaluated.	X		
Assumptions may not reflect actual conditions.			X

Exposure characteristics depend largely on activity patterns that are not as easy to generalize as population characteristics. For example, the proposed frequency of exposure to surface water in the drainage ditch assumes that this surface water body is not used for regular wading, although this could conceivably happen at this location. Uncertainties are inherent to various degrees with the remaining exposure characteristics. Exposure doses based on the selected exposure parameters may overestimate or underestimate the actual exposure doses.

The chemical intakes determined in Section 3.4.3 represent reasonable maximum exposure (RME) conditions. Exposure factors, with the exceptions of body weight and surface areas, represent upper-bound estimates of exposure conditions. Alternative exposure factors can be considered that represent average (central tendency) estimates of exposure conditions. This provides a measure of central tendency for the predicted chemical doses and estimated risks. An estimate of the uncertainty associated with the exposure estimates is also provided, by an examination of the uncertainty associated with the exposure estimates is also provided, by an examination of the ways in which using alternative values for numerical exposure parameters can change the resulting exposure estimates.

RME and average exposure factors are compared in Table 3-3 for specific pathways. Summary intake factors for specific pathways are also presented. The summary intake factors are calculated by solving the LADI and AT equations presented for each pathway in Section 3.4.3, with the exception of contaminant concentration values.

The ratios of the average summary intake factors to RME summary intake factors are presented in Table 3-4. This ratio provides an estimate of the magnitude of difference that occurs between average and RME intake factor values. As indicated by the ratios, the difference between the intake factors is less than an order of magnitude, with the exception of the dermal contact with soil pathway for carcinogens.

Total cancer risks and hazard quotients for the residential scenario using central tendency exposure assumptions are presented in Section 5.0 in Tables 5-9 and 5-10. These risks can be determined from the products of the RME pathway risks and the average to RME intake factor ratios, since the relationship is linear. The residential scenario is selected because average exposure factors for this scenario are recommended by EPA and all the exposure pathways are considered. Exposure pathways include soil ingestion and dermal contact, particulate and vapor inhalation, and ground-water ingestion and bathing exposures (that is, dermal contact and inhalation of volatile while showering). The risks determined for the residential scenario are also the most conservative, based on the longer exposure durations assumed.

TABLE 3-3

**RME AND AVERAGE EXPOSURE FACTORS
AND SUMMARY INTAKE FACTORS FOR
RESIDENTIAL PATHWAYS**

	<u>RME</u> <u>Exposure Factors</u>		<u>Central Tendency</u> <u>Exposure Factors</u>		<u>Reference</u>
	<u>Non-Carcinogens</u>	<u>Carcinogens</u>	<u>Non-Carcinogens</u>	<u>Carcinogens</u>	
<u>Residential Scenarios</u>					
<u>Water Ingestion - Adults Only</u>					
Intake Rate	2 l/day	2 l/day	1.4 l/day	1.4 l/day	EPA 1989
Exposure Frequency	350 day/year	350 day/year	275 day/year	275 day/year	EPA 1991b
Exposure Duration	30 year	30 year	9 year	9 year	EPA 1989
Body Weight	70 kg	70 kg	70 kg	70 kg	EPA 1991a
Averaging Time	30 year	70 year	9 year	10 year	EPA 1991a
Summary Intake Factor	2.7×10^{-2} L <u>(kg BW x day)</u>	1.2×10^{-2} L <u>(kg BW x day)</u>	1.5×10^{-2} L <u>(kg BW x day)</u>	1.9×10^{-3} L <u>$\frac{1H_2O}{(kg BW \times day)}$</u>	
<u>Soil & Dust Ingestion - Adults and Children</u>					
Intake Rate	200 mg/day (child) 100 mg/day (adult)	200 mg/day (child) 100 mg/day (adult)	100 mg/day (child & adult)	100 mg/day	EPA 1990, 1991
Exposure Frequency	350 day/year	350 day/year	275 day/year	275 day/year	EPA 1991b
Exposure Duration	6 year (child) 24 year (adult)	6 year (child) 24 year (adult)	2 year (child) 9 year (adult)	2 year (child) 9 year (adult)	EPA 1990 EPA 1989
Body Weight	15 kg (child) 70 kg (adult)	15 kg (child) 70 kg (adult)	15 year (child) 70 kg (adult)	15 year (child) 70 kg (adult)	EPA 1991a
Averaging Time	30 year	70 year	11 year (child & adult)	70 year	EPA 1991a
Summary Intake Factor	3.7×10^{-6} <u>$\frac{kg \text{ soil}}{(kg BW \times day)}$</u>	1.6×10^{-6} <u>$\frac{kg \text{ soil}}{(kg BW \times day)}$</u>	1.8×10^{-6} <u>$\frac{kg \text{ soil}}{(kg BW \times day)}$</u>	2.8×10^{-7} <u>$\frac{kg \text{ soil}}{(kg BW \times day)}$</u>	
<u>Inhalation - Adults Only</u>					
Intake Rate	20 m3/day	20 m3/day	14-15 m3/day	14-15 m3/day	EPA 1991
Exposure Frequency	350 day/year	350 day/year	275 day/year	275 day/year	EPA 1991b
Exposure Duration	30 year	30 year	9 year	9 year	EPA 1989
Body Weight	70 kg	70 kg	70 kg	70 kg	EPA 1991
Averaging Time	30 year	70 year	9 year	70 year	EPA 1991
Summary Intake Factor	0.27 <u>$\frac{m^3 \text{ air}}{(kg \times day)}$</u>	0.12 <u>$\frac{m^3 \text{ air}}{(kg \times day)}$</u>	0.16 <u>$\frac{m^3 \text{ air}}{(kg \times day)}$</u>	0.02 <u>$\frac{m^3 \text{ air}}{(kg \times day)}$</u>	

TABLE 3-3 (Continued)

Reference	RME Exposure Factors		Average Exposure Factors		
	Non-Carcinogens	Carcinogens	Non-Carcinogens	Carcinogens	
<u>Dermal Contact with Soil - Adults and Children</u>					
Contact Rate	1.0 mg/cm2	1.0 mg/cm2	0.2 mg/cm2	0.2 mg/cm2	EPA 1992
Exposure Frequency	350 day/year	350 day/year	275 day/year	275 day/year	EPA 1991b
Skin Surface Area	1,048 cm2 (child)	1,048 cm2 (child)	1,048 cm2 (child)	1,048 cm2 (child)	
Exposure	2,666 cm (adult)	2,666 cm (adult)	2,666 cm (adult)	2,666 cm (adult)	
Exposure Duration	6 year (child)	6 year (child)	2 year (child)	2 year (child)	EPA 1990
	24 year (adult)	24 year (adult)	9 year (adult)	9 year (adult)	EPA 1989
Body Weight	15 kg (child)	15 kg (child)	15 kg (child)	15 kg (child)	EPA 1991a
	70 kg (adult)	70 kg (adult)	70 kg (adult)	70 kg (adult)	EPA 1991a
Averaging Time	30 year	70 year	11 year (child & adult)	70 year	EPA 1991a
Absorption	Chemical Specific		Chemical Specific		(17)
Summary Intake Factor	$4.2 \times 10^{-5} \times \text{abs}$ $\frac{\text{kg soil}}{(\text{kg BW} \times \text{day})}$	$1.8 \times 10^{-5} \times \text{abs}$ $\frac{\text{kg soil}}{(\text{kg BW} \times \text{day})}$	$6.6 \times 10^{-6} \times \text{abs}$ $\frac{\text{kg soil}}{(\text{kg BW} \times \text{day})}$	$1.0 \times 10^{-6} \times \text{abs}$ $\frac{\text{kg soil}}{(\text{kg BW} \times \text{day})}$	
<u>Dermal Contact with Water - Adults Only</u>					
Contact Rate	0.25 hr (bathing)	0.24 hr (bathing)	0.17 hr	0.17 hr	EPA 1992
Exposure Frequency	350 day/year (bathing)	350 day/year (bathing)	275 day/year (bathing)	275 day/year (bathing)	EPA 1991b
Skin Surface Area Exposed	20,000 cm2	20,000 cm2	20,000 cm2	20,000 cm2	
Exposure Duration	30 year	30 year	9 year	9 year	EP 99
Body Weight	70 kg	70 kg	70 kg	70 kg	EF 99
Averaging Time	30 year	70 year	9 year	70 year	EPA 1991a
Permeability Coefficient	Chemical Specific		Chemical Specific		
Summary Intake Factor bathing	$6.8 \times 10^{-2} \times \text{Kp}$ $\frac{1\text{H}_2\text{O}}{\text{kg BW} \times \text{day}}$	$2.9 \times 10^{-2} \times \text{Kp}$ $\frac{1\text{H}_2\text{O}}{\text{kg BW} \times \text{day}}$	$3.7 \times 10^{-2} \text{Kp}$ $\frac{1\text{H}_2\text{O}}{\text{kg BW} \times \text{day}}$	$4.7 \times 10^{-3} \times \text{Kp}$ $\frac{1\text{H}_2\text{O}}{\text{kg BW} \times \text{day}}$	
<u>Inhalation of Volatiles While Showering - Adults Only</u>					
Intake Rate	0.6 m3/hr	0.6 m3/hr	0.6 m3/hr	0.6 m3/hr	
Exposure time	0.25 hr	0.25 hr	0.17 hr	0.17 hr	EPA 1992
Exposure Frequency	350 day/year	350 day/year	275 day/year	275 day/year	EPA 1991b
Exposure Duration	30 years	30 years	9 years	9 years	EPA 1989
Body Weight	70 kg	70 kg	70 kg	70 kg	EPA 1991
Averaging Time	30 years	70 years	9 years	70 years	EPA 1991a
Summary Intake Factor	2×10^{-3} $\frac{\text{m3 air}}{(\text{mg} \times \text{day})}$	8.2×10^{-4} $\frac{\text{m3 air}}{(\text{mg} \times \text{day})}$	1.1×10^{-3} $\frac{\text{m3 air}}{(\text{mg} \times \text{day})}$	1.4×10^{-4} $\frac{\text{m3 air}}{(\text{mg} \times \text{day})}$	

TABLE 3-4
RATIO OF CENTRAL TENDENCY INTAKE FACTORS TO RME
INTAKE FACTORS, RESIDENTIAL PATHWAYS

<u>Scenario</u>	<u>Average/Rme Summary Intake Factor Ratio</u>
Water Ingestion - Adults Only	
Noncarcinogens	0.55
Carcinogens	0.16
Soil & Dust Ingestion - Adults and Children	
Noncarcinogens	0.49
Carcinogens	0.17
Inhalation - Adults only	
Noncarcinogens	0.59
Carcinogens	0.17
Dermal Contact with Soil - Adults and Children	
Noncarcinogens	0.16
Carcinogens	0.05
Dermal Contact with Water While Bathing - Adults Only	
Noncarcinogens	0.54
Carcinogens	0.16
Inhalation of Volatiles While Showering - Adults Only	
Noncarcinogens	0.55
Carcinogens	0.16

As noted in Section 3.4, EPA (1989b) recommends that adjustments be made to match the dermal exposure estimates (expressed as absorbed dose) with the toxicity values (expressed as administered dose). These adjustments require specific knowledge of the tests used to develop toxicity values for each contaminant at the site, and the percentage of the dose administered in each test that was potentially absorbed by the test organisms. Since this information is not readily available, toxicity values were not adjusted in this risk assessment. This may result in an under estimation of actual risks, since the toxic effects observed in testing may have resulted from an absorbed dose that is smaller than the known administered dose.

3.5.3 Assumption of Steady-State Conditions

Estimated exposure doses are based on an assumption of steady-state conditions. Chemical concentrations used to estimate the exposure doses are based on data from the RI. The inherent assumption is that current and future chemical concentrations are the same as those measured in the RI. This assumption ignores the effect of various fate-and-transport mechanisms, which will alter the composition and distribution of chemicals present in the various media, as well as the impact of possible removal or remedial actions that would reduce chemical concentrations. In general, the assumption of steady-state conditions probably results in an overestimation of chemical concentrations and resulting exposure doses.

3.5.4 Environmental Chemical Characterization.

It is impossible to completely characterize the nature and extent of chemicals in the environment at the Lenz Oil site. Instead, the various environmental media are sampled to estimate environmental chemical concentrations and to assess which chemicals are present as a result of chemical releases at the site. Because no sampling can completely and accurately characterize environmental conditions, the exposure dose calculations will be somewhat uncertain.

Uncertainties are introduced into exposure dose calculations during collection, analysis, and evaluation of environmental chemical data. Six potentially significant areas are discussed below: (1) seasonal variations in environmental concentrations; (2) nonrandom sample collection; (3) assumption of uniform concentrations; (4) treatment of nondetection results; (5) comparison to background concentrations; and (6) use of unfiltered versus filtered sampling results.

3.5.4.1 Seasonal Variations

This RA is based on data collected as part of the RI. Although these data represent the most thorough and complete sampling efforts, samples representative of each season were not taken for

all media. Therefore, the data do not fully reflect seasonal variations. This does not affect soil concentrations, which are unlikely to vary seasonally, but it could affect results for surface water and groundwater concentrations. Not using representative sample data for all seasons may result in an overestimation or underestimation of actual environmental concentrations and corresponding exposure doses.

3.5.4.2 Nonrandom Sample Collection

Samples were not collected randomly. Generally, downgradient sampling points were selected to identify the magnitude of environmental chemical contamination and not to identify representative concentrations. For example, surface soil sampling locations were chosen based on information on the areas that were most likely to have soil contamination. Therefore, exposure doses based on these soil samples as well as on other nonrandom samples may overestimate actual exposure doses.

3.5.4.3 Assumption of Uniform Concentrations

Contaminant concentrations in each medium are assumed to be uniform throughout a particular exposure area based on samples taken from specific points within that area. For example, a high contaminant concentration in a sample from a "hot spot" in soil could drive the soil exposure concentration of that contaminant up for an entire area. Conversely, "hot spots" may not have been sampled and, therefore, may not have been adequately represented in the exposure concentration for an area. Assumption of uniform concentrations may lead to overestimation or underestimation of actual exposures.

3.5.4.4 Treatment of Nondetection Results

During production of environmental statistics, nondetection results were replaced with a value equal to one-half the sample quantification limit. This procedure introduces uncertainty because the sample result could be less than or greater than the substituted value. However, the procedure is more conservative than replacing ND results with zero (thus assuming that a chemical would not be present even if the analysis is very sensitive). This treatment of ND results may result in an overestimation or underestimation of environmentally significant chemicals of potential concern.

The degree of uncertainty introduced is roughly proportional to the frequency of ND results within a particular sample set. Statistics calculated from a sample set that contains a single ND result are less uncertain than statistics calculated from a sample set in which most results are ND results.

3.5.4.5 Comparison to Background Concentrations

The statistical comparison of potentially affected or downgradient samples to background samples was a significant step in identifying chemicals of potential concern. Selecting appropriate background samples is critical to the accuracy and usefulness of such comparisons. For some media, such as soils, appropriate site-specific background samples were more easily identified than for others.

The statistical comparisons to background samples were not accepted simply at face value. The nature of the background samples was also considered in selecting chemicals of potential concern. However, a degree of uncertainty is introduced whenever the most appropriate background samples cannot be identified and a less appropriate set of values must be used. This uncertainty may result in an overestimation or underestimation of environmentally significant chemicals of potential concern.

3.5.4.6 Unfiltered Versus Filtered Results

U.S. EPA guidance requires that exposures and risks related to groundwater be based on unfiltered results (EPA, 1989). In this RA, exposure and risk calculations are based on unfiltered groundwater results (organics and inorganics). Some residents may in fact filter groundwater before using it for drinking purposes; other may not. Furthermore, those who filter their water may not filter it as extensively as the RI samples were filtered. Therefore, the risks based on unfiltered results may overestimate the actual risks related to metals exposure for persons who filter their groundwater. However, risks calculated using filtered groundwater results may have underestimated actual risks related to metals exposure for these people.

3.5.5 Modeling Procedures

Models were used to determine contaminant concentrations in outdoor air resulting from particulate emission and volatilization from excavation and construction activities, and exposure to VOCs during showering. Numerous assumptions are included in these models. These assumptions introduce uncertainty to the degree that they do not reflect actual conditions. Use of the models may lead to overestimation or underestimation of actual environmental concentrations.

3.6 SUMMARY OF EXPOSURE ASSESSMENT

RME concentrations listed in Appendix C are factored into the equations described in Section 3.4 to determine potential chemical intake. The intake values are then carried through the risk

assessment steps described in the following sections to determine carcinogenic and noncarcinogenic health effects. Appendix J includes a summary of chemical concentrations, estimated intakes, and health risks.

4.0 TOXICITY ASSESSMENT

This section summarizes the toxicologic basis for all compound-specific toxicity data, using available dose-response information. The section is divided into three parts. Section 4.1 presents an overview of the types of dose response information used to characterize noncarcinogenic and carcinogenic risks at CERCLA sites. Toxicity values including RfDs for noncarcinogenic effects and slope factors for carcinogenic effects are presented. Chemicals for which no toxicity values are available are also discussed. Section 4.2 is a brief discussion of some of the assumptions and uncertainties regarding the toxicity values used to characterize risks. Finally, Section 4.3 presents brief summaries of available toxicologic information for chemicals of potential concern and some TICs found at the Lenz Oil site. More complete toxicity profiles (including specific references) are presented in Appendix H.

4.1 DOSE RESPONSE INFORMATION

In developing risk assessment methods, EPA recognizes fundamental differences between carcinogenic and noncarcinogenic dose-response variables used to estimate risks. Because of these differences, human health risk is characterized separately for the noncarcinogenic and carcinogenic effects related to chemical contaminants. Some chemicals of concern may have both noncarcinogenic and carcinogenic effects, although in most cases EPA has published toxicity criteria for only the more sensitive type of toxic effect, supporting the most restrictive toxicological criteria.

Typically, EPA uses chronic rather than acute toxicity data in developing toxicity criteria. Acute toxicity data are derived from studies in which animals are exposed to high doses of a chemical over a short time period. In contrast, chronic exposure refers to low level exposure over most of a lifetime.

4.1.1 TOXICITY INFORMATION FOR NONCARCINOGENIC EFFECTS

The key dose-response variable used in quantitative risk assessment of noncarcinogenic effects is the reference dose (RfD) value. The RfD (expressed in units of mg/kg/day) for a specific chemical is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a portion of the lifetime (EPA, 1992c). It is usually based on the relationship between the dose of a noncarcinogen and the frequency of systemic toxic effects in experimental animals or humans, and assumes that there is a threshold below which toxic effects are not observed. The threshold of observed effects is divided by an uncertainty factor to derive an RfD

that protects the most sensitive members of the population. Uncertainty factors are discussed in Section 4.4.

Once an RfD for a compound has been verified by EPA it is used to evaluate long-term noncarcinogenic risks at the site. This "acceptable" dose is compared to the expected dose (calculated in the exposure assessment) to determine whether chronic effects might occur. If predicted exposure concentrations are below the RfD, no adverse chronic health effects are expected.

4.1.2 TOXICITY INFORMATION FOR CARCINOGENIC EFFECTS

The key dose-response variable used in quantitative risk assessment of carcinogenic effects is the slope factor.

For chemicals classified by EPA as potential human carcinogens, risk is evaluated differently than it is for the noncarcinogenic effects of chemicals. Typically, carcinogenicity studies are conducted at high doses. To evaluate the probability of developing cancer at lower doses more frequently encountered by the public, the linearized multistage model is applied to the data. This mathematical model expresses excess cancer risk as a function of exposure and is based on the conservative assumption that even a single, low-dose exposure to a carcinogen may result in cancer.

From the model, the 95th percentile confidence limit of the slope from the dose response curve is calculated. This slope factor, expressed in units of $(\text{mg/kg/day})^{-1}$ provides a conservative estimate of the probability of cancer development from a lifetime of exposure to a particular level of a potential carcinogen. By definition, there is only a 5 percent chance that the probability may actually be higher.

Compound-specific slope factors are multiplied by dose from a given exposure route to assess the upper-bound cancer risk associated with that dose.

EPA assigns weight-of-evidence classifications to potential carcinogens. Under this system, chemicals are classified as belonging to one of six groups -- Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A chemicals are agents for which there are sufficient data is limited (B1) or inadequate (B2) evidence of carcinogenicity from human exposure studies, but there is sufficient evidence of carcinogenicity from animal studies. Group C chemicals are agents for which there is limited evidence of carcinogenicity from animal studies. Group D chemicals are characterized by an inadequate carcinogenicity database. Chemicals exhibiting no evidence of a carcinogenic response in humans or animals are assigned to Group E.

Available dose-response information for quantitative risk assessment is summarized in Tables 4-1 through 4-4 for the chemicals of concern. Table 4-1 contains oral reference doses and Table 4-2 lists inhalation reference doses. The EPA weight-of-evidence classifications for the carcinogens involved in this risk assessment are presented in Tables 4-3 and 4-4. Table 4-3 provides oral slope factors, and inhalation slope factors are in Table 4-4. RfD values and confidence ratings for noncarcinogens, and slope factors and weight-of-evidence ratings for carcinogens were collected from the EPA Integrated Risk Information System (IRIS) database (EPA, 1992b), and the EPA Health Effects Assessment Summary Tables (HEAST), Annual FY 1992 (EPA, 1992c). Supporting information was obtained from consultation with EPA's Environmental Criteria and Assessment Office (ECAO).

4.1.3 CHEMICALS WITH NO EPA TOXICITY VALUES

For some chemicals, RfDs and slope factors were available only for the oral route of exposure. For these substances, the RfDs and slope factors for the oral route of exposure were also used to estimate dermal exposure. Only inhalation RfDs and slope factors were used to estimate inhalation exposure. No route-to-route extrapolation was attempted, as specified in EPA risk assessment guidance (EPA, 1989b). Since carcinogenic chemicals may also cause noncarcinogenic health effects, RfD values (where available) were compiled for carcinogenic chemicals and were used to evaluate the potential noncarcinogenic effects of carcinogens.

For some chemicals, no RfD or slope factor values were located in either the IRIS database or HEAST. For chemicals with no toxicity values, risks were not quantified.

A large number of TICs were detected in relatively high concentrations at the Lenz Oil site. Most of them were hydrocarbons typically associated with petroleum distillates and products. Therefore, a discussion of petroleum distillates, decane and octane is included in Section 4.5. A detailed discussion of gasoline toxicity is included in Appendix H of this report.

4.2 ASSUMPTIONS AND UNCERTAINTIES REGARDING TOXICITY VALUES

Several assumptions were made in compiling and using dose-response information for some of the chemicals of concern. For example, only total trace metal concentrations were measured for each metal at the site, not distinct species concentrations. Consequently, the RfD for chromium III

TABLE 4-1
ORAL REFERENCE DOSES FOR CONTAMINANTS OF CONCERN

Compound	Chronic Oral RfD (mg/kg-day)	Confidence Level	Critical Effect	RfD Basis/ Source	Uncertainty/ Modifying Factors	Subchronic ^a Oral RfD (mg/kg-day)
<u>Volatile Organics</u>						
Acetone	1E-1	low	kidney damage	gavage/IRIS	1,000	1E+0
Carbon disulfide	1E-1	medium	phytotoxicity	rabbit/IRIS	100	
Chlorobenzene	2E-2	medium	liver effects	dog/IRIS	1,000	2E-1
Chloroform	1E-2	medium	liver damage	gavage/IRIS	1,000	
1,1-Dichloroethane	1E-1	—	none observed	Air/HEAST	1,000	1E+0
1,1-Dichloroethene	9E-3	medium	liver damage	water/IRIS	1,000	
trans-1,2-Dichloroethene	2E-2	low	cell death	garage/IRIS	3,000	2E-1
cis-1,2-Dichloroethene	1E-2	low	decreased hemoglobin	rat/gavage/HEAST	—	1E-1
1,3-Dichloropropene	3E-4	low	increased organ wt.	rat/IRIS	10,000	(3E-3) ^b
Ethylbenzene	1E-1	low	liver/kidney effects	gavage/IRIS	1,000	1E+0 ^b
Methylene chloride	6E-2	—	liver	drinking/IRIS	100	6E-2
Tetrachloroethene	1E-2	medium	liver damage	gavage/IRIS	1,000	
Toluene	2E-1	medium	liver and kidney weight changes	gavage/IRIS	1,000	2E+0
Total xylenes	2E+0	medium	lower weight	gavage/IRIS	100	4E+0
1,1,1-Trichloroethane	9E-2	—	liver toxicity	oral/HEAST	1,000	9E-1
1,1,2-Trichloroethane	4E-3	medium	blood effects	Mouse/IRIS	1,000	
<u>Semivolatile Organics</u>						
Acenaphthene	6E-2	low	liver effects	Mouse/IRIS	3,000	6E-1
Anthracene	3E-1	low	none observed	garage/IRIS	3,000	3E+0
Bis (2-ethylhexyl) phthalate	2E-2	—	increased liver wt.	guinea pig/IRIS	1,000	2E-2
Butyl benzyl phthalate	2E-1	low	liver effects	diet/IRIS	1,000	2E+0
1,2-Dichlorobenzene	9E-2	low	none observed	/IRIS	1,000	9E-1
Di-n-Butyl Phthalate	1E-1	low	mortality	rat/IRIS	100	1E+0
Fluoranthene	4E-2	low	liver damage	gavage/IRIS	3,000	4E-1
Fluorene	4E-2	low	blood effects	Mouse/IRIS	3,000	4E-1
Hexachlorocyclopentadiene	7E-3	low	stomach lesions	rat/IRIS	1,000	
Naphthalene	4E-2	—	decreased wt.	gavage/HEAST	1,000	4E-2
Di-n-Octyl Phthalate	2E-2	—	kidney/liver effects	HEAST/diet/rat	1,000	2E-2
Phenol	6E-1	low	Reduced fetal wt.	rat/IRIS	100	6E-1
Pyrene	3E-2	low	kidney effects	gavage/IRIS	3,000	3E-1

TABLE 4-1 (continued)
ORAL REFERENCE DOSES FOR CONTAMINANTS OF CONCERN

Compound	Chronic Oral RfD (mg/kg-day)	Confidence Level	Critical Effect	RfD Basis/ Source	Uncertainty/ Modifying Factors	Subchronic ^a Oral RfD (mg/kg-day)
<u>Pesticides/PCBs</u>						
Aldrin	3E-5	medium	liver damage	diet/IRIS	1,000	3E-5
Chlordane	6E-5	—	liver effects	rat diet/IRIS	1,000	6E-5
DDT	5E-4	medium	liver damage	diet/IRIS	100	5E-4
Dieldrin	5E-5	—	liver toxicity	rat diet/IRIS	100	—
gamma-Hexachlorocyclohexane	3E-4	medium	liver effects	rat diet/IRIS	1,000	—
<u>Metals</u>						
Beryllium	5E-3	—	—	IRIS	100	—
Cadmium	1E-3 food, 5E-4 water	high	kidney damage	human/IRIS	10	—
Chromium III	1E+0	low	no effects	water/IRIS	500	2E-2
Copper	—	—	—	—	—	—
Zinc	2E-1	—	—	HEAST	—	2E-1

a Subchronic oral RfDs used for short-term future worker risk assessment.

b Subchronic RfD for ethylbenzene is for inhalation exposure.

TABLE 4-2
INHALATION REFERENCE DOSES FOR CONTAMINANTS OF CONCERN

Compound	Inhalation RfD (mg/kg-day) ⁻¹	Confidence Level	Critical Effect	RfD Basis/ Source	Uncertainty/ Modifying Factors	Inhalation RfD (mg/kg-day) ⁻¹
<u>Volatile Organics</u>						
Carbon disulfide	3E-3	medium	phytotoxicity	rat/HEAST	1,000	—
1,3-Dichloropropene	6E-3	high	respiratory effects	mouse/IRIS	30	6E-3
Ethylbenzene	3E-1	low	developmental	air/IRIS	300	3E-1
Toluene	4E-1	—	CNS effects	HEAST	—	6E-1

TABLE 4-3
ORAL SLOPE FACTORS FOR CONTAMINANTS OF CONCERN

Compounds	Oral Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	Basis/ Source
<u>Volatile Organics</u>				
Chloroform	6.1E-3	B2	kidney	water/IRIS
trans-1,3-Dichloropropene	1.8E-1	B2	multiple	gavage/HEAST
1,2-Dichloroethane	9.1E-2	B2	circ. system	gavage/IRIS
1,1-Dichloroethene	6E-1	C	adrenal	inhalation/IRIS
1,1,2,2-Tetrachloroethane	2E-1	C	liver	gavage/HEAST
Tetrachloroethene	5.1E-2	B2	liver	mouse gavage/HEAST
1,1,2-Trichloroethane	5.7E-2	C	liver	mouse/IRIS
Trichloroethene	1.1E-2	B2	liver	mouse gavage/HEAST
Vinyl chloride	1.9E+0	A	lung	diet/HEAST
<u>Semivolatile Organics</u>				
Benzo(a)pyrene	5.8	B2	stomach	diet/EPA 1992
Bis(2-ethylhexyl)phthalate	1.4E-2	B2	liver	rat/IRIS
3,3-dichlorobenzidine	4.5E-1	—	—	IRIS
<u>Pesticides/PCBs</u>				
Aldrin	1.7E+1	B2	liver	diet/IRIS
Chlordane	1.3E+0	B2	liver	mouse diet/HEAST
DDD	2.4E+1	B2	liver	mouse diet/HEAST
DDE	3.4E+1	B2	liver	mouse diet/HEAST
DDT	3.4E-1	B2	liver	diet/IRIS
gamma-hexachlorocyclohexane	1.3E+0	B2-C	liver	diet/HEAST
Total PCBs	7.7E+0	B2	liver	diet/IRIS
Toxaphene	1.1E+0	B2	liver	mouse diet/HEAST

TABLE 4-4
INHALATION SLOPE FACTORS FOR CONTAMINANTS OF CONCERN

Compounds	Inhalation Slope Factor (mg/kg-day) ⁻¹	Weight of Evidence	Type of Cancer	Basis/ Source
<u>Volatile Organics</u>				
Benzene	2.9E-2	A	leukemia	human/IRIS
Chloroform	8.1E-2	B2	liver	gavage/IRIS
trans-1,3-Dichloropropene	1.3E-1	B2	lung	inhalation/HEAST
1,2-Dichloroethane	9.1E-2	C	circ. system	gavage/IRIS
1,1-Dichloroethene	1.2E+0	C	kidney	inhalation/IRIS
1,1,2,2-Tetrachloroethane	2E-1	C	liver	mouse/IRIS
Tetrachloroethene ^a	1.8E-3	B2	leukemia	inhalation/IRIS
1,1,2-Trichloroethane	5.6E-2	C	liver	mouse/IRIS
Trichloroethene	1.7E-2	B2	lung	ihl. mouse/HEAST
Vinyl chloride	2.9E-1	A	liver	ihl. rat/HEAST
<u>Semivolatile Organics</u>				
Benzo(a)pyrene	6.1E+0	B2	resp. tract	ihl.hamster/HEAST
<u>Pesticides/PCBs</u>				
Aldrin	1.7E+1	B2	liver	diet/IRIS
Chlordane	1.3E+0	B2	liver	diet/HEAST
DDT	3.4E-1	B2	liver	diet/IRIS
Dieldrin	1.6E+1	B2	liver	diet/HEAST
Toxaphene	1.1E+0	B2	liver	diet/HEAST
<u>Metals</u>				
Cadmium	6.1E+0	B1	resp. tract	human/IRIS

IRIS = Integrated Risk Information System, On-line Data Base, 1992
HEAST = Health Effects Assessment Summary Tables, FY 1991

^a SF calculated from air unit risk.

(1 mg/kg/day) was used instead of the RfD for chromium VI (0.005 mg/kg/day) to provide a more realistic estimate of potential risks associated with chromium ingestion.

RfDs and slope factors must be viewed in light of uncertainties and gaps in toxicological data. Information on toxic effects in humans is often limited to historical cases of accidental exposures. Studies must be conducted with specially bred homogenous animal species, and the results extrapolated to the heterogenous human population. The problems with this approach include the presence of sensitive subpopulations among humans and differences in physiology, target organs, metabolism, sensitivity, and detoxification capabilities between humans and animals.

In addition, high-dose, short-term animal studies may not be applicable to the low-level, long-term, exposures that humans are more likely to experience. The quality of the animal study may introduce additional uncertainty.

The uncertainties discussed above are addressed by dividing the no observable adverse effect level (NOAEL) from animal studies by uncertainty factors of 10. These uncertainties are incorporated into RfDs and slope factors. Uncertainty factors are applied to data in the following cases (EPA, 1989b):

- To account for variation in the general population (to protect sensitive subpopulations)
- To extrapolate the data from animals to humans
- To adjust for using an NOAEL from a subchronic, rather than a chronic study
- To adjust for using an LOAEL (lowest observable effect level) instead of an NOAEL in developing an RfD.

A modifying factor ranging from 1 to 10 is also applied to the data to reflect any other uncertainty based upon professional opinion.

4.3 TOXICITY SUMMARIES

Contaminants found at the Lenz Oil site have varying effects on humans. Detailed summaries of known effects of all of the contaminants along with references are provided in Appendix H. Metals are discussed first, followed by organic compounds.

It is never possible to predict with 100 percent certainty the effect that a given concentration of a chemical will have on a given individual because each individual reacts differently. For some chemicals, certain classifications of persons (such as infants or the elderly) are known to be more susceptible. Furthermore, the standard values given in the preceding section generally involve two

extrapolations: from animals to humans, and from a high dose (giving adverse effects) to a low dose. Uncertainty factors and similar devices are used to account for errors in extrapolation. Finally, the most difficult factor to estimate is the interaction among contaminants and between contaminants and other factors. Where particular uncertainties and interactions are known, these are pointed out in the individual summaries.

Brief summaries of the contaminants posing the greatest carcinogenic risk and highest hazard quotients at the Lenz Oil site are provided in this section. These contaminants are carcinogenic PAHs, PCBs, cadmium, chromium, chlordane, lindane (gamma-BHC), and TCE. All of the toxicity values used in risk calculations are provided in Tables 4-1 through 4-4.

Carcinogenic PAHs

PAHs are generally found as a highly complex mixture in the products of incomplete combustion (coal soot, cigarette smoke, motor vehicle exhaust, and so on). Seventeen PAHs are included in U.S. EPA's hazardous substances list, but few are well studied. The most recent general evaluation (National Institute for Environmental Health Sciences, 1989) concludes that the following PAHs detected at the Lenz Oil site are probably carcinogenic:

- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(j)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene (BAP)
- Dibenzo(a,h)anthracene
- Indeno(1,2,3-cd)pyrene

Another study added chrysene to the list. The slope factor for BAP was modified by relative potency estimates presented in a study by Clement (1988).

Dermal absorption of BAP and other PAHs has been demonstrated indirectly, because toxic effects have been seen after oral and inhalation exposure. PAHs are oxidized in the liver by an enzyme, aryl hydrocarbon hydroxylase (AHH), to the epoxide, which hydrolyses to the hydroxy or dihydroxy derivative. The metabolites are the active forms of the chemicals; variations in the formation (amount, rate, products) of these metabolites account for the different effects of the various PAHs. PAHs also cause the synthesis of greater quantities of AHH and other drug-metabolizing enzymes; therefore, simultaneous exposure to PAHs and other toxicants increases or decreases the toxicity of the other toxicants. A few nonmetabolic interactions also exist. For example, BAP increases the

cardiac sensitization effects of trichloroethene. PAHs are excreted as a large variety of oxidized metabolites and conjugated metabolites, mostly through the bile into the feces.

The carcinogenic PAHs are also immunotoxic; the more potent carcinogens are also more potent immunosuppressants.

PAHs have little, if any, reproductive toxicity in the few available studies, except in parenteral studies of BAP in rodents. Most adverse effects were nonspecific, such as decreased birth weight and reproductive performance, and were at relatively high doses. The potency of BAP as a reproductive toxicant was markedly affected by inborn differences in metabolism among various strains of mouse, emphasizing the importance of metabolism to the toxicity of these compounds.

PCBs

In humans, the primary acute toxic effect of PCBs is chloracne. No distinctive acute effects have been reported in animals. Repeated dose toxicity in humans is known as "Yusho disease" after the residents of Yusho, Japan, who ate rice bran oil contaminated with PCBs for several months. After a latent period of several months, the victims developed chloracne, pigmentation of skin areas, visual disturbances, gastrointestinal distress, jaundice, and lethargy. Infants from exposed mothers had low birth weight and pigment blotches. Some observers have ascribed some or even most of this toxicity to the chemically related polychlorinated dibenzofurans (PCDFs) in the mixture with the PCBs. These PCDFs are decomposition products of PCBs, formed in large quantities by fires involving PCBs.

PCBs are carcinogenic in some animal studies. There is some indication from occupational and Yusho exposures that PCBs are carcinogenic in humans, but this evidence is not definitive because of other, simultaneous exposures.

PCBs have reproductive toxicity, based on results of the few animal studies, the Yusho incident a more recent similar incident in Taiwan, and a study in mothers eating PCB-contaminated fish. Effects were similar to adult toxicity; nonspecific effects included low birth weight and spontaneous abortions or still births and skin lesions. In the few studies found, PCBs have little or no mutagenicity.

Cadmium

The extent to which cadmium compounds are absorbed depends on their solubility. Typically, about 5 percent of an oral dose is absorbed. However, various dietary factors such as calcium and iron

deficiencies may stimulate absorption. Cadmium concentrates in the liver and kidneys. Excretion via the urine is very slow; the biologic half-life of cadmium has been estimated at between 19 and 38 years.

The acute toxic effects of cadmium are primarily local irritation. Oral doses produce nausea, vomiting, salivation, diarrhea, and abdominal cramps. Immediate death may be caused by shock and dehydration; renal and cardiopulmonary failure may cause death a week or so after ingestion. Several epidemics of gastrointestinal distress have resulted when cadmium leached from ceramic containers containing acid media such as fruit juices. Zinc and selenium can counteract cadmium toxicity.

Chronic toxicity has been seen primarily in workers exposed to cadmium fumes and dusts, and in Japanese villagers who drank cadmium-contaminated water and ate rice grown in that water. The Japanese villagers had extensive kidney damage. Symptoms initially noted as severe joint and muscle pains (hence the name "itai-itai" or "ouch-ouch" disease) progressed to osteomalacia with consequent multiple fractures. Menopause and dietary deficiencies may have aggravated the effects of the cadmium toxicity.

The carcinogenicity of cadmium has been disputed, with much recent research resulting in changed conclusions. Epidemiologic studies have shown limited evidence of lung and other cancers after cadmium inhalation; therefore, cadmium is classified by EPA as a probable human carcinogen. No animal studies have found cadmium to be carcinogenic after ingestion. If cadmium is carcinogenic after ingestion, its potency is no more than 1/100 that of inhalation.

Chromium

The toxicology of chromium is complicated because of its complex chemistry and many oxidation states. Chromic (trivalent) chromium is the most common state, but chromate (hexavalent) chromium is the most toxic. The oral reference dose for chromium III was used to evaluate exposure to chromium in environmental media at the Lenz Oil site because available information suggest that conditions will favor this form of chromium.

Chromium is an essential trace mineral involved in a number of the enzyme systems used in carbohydrate metabolism. For example, chromium is necessary for insulin to produce its physiological effects. There have been reports of chromium deficiency in infants and elderly persons who suffer from malnutrition.

Chromium is absorbed from the lungs and gastrointestinal tract, but not completely. Chromate (hexavalent) chromium is better absorbed from the gut than chromic (trivalent) chromium, but only chromate is absorbed through the skin. It is likely that these differences in absorption account for most, if not all, of the observed differences in toxicity among the oxidation states. Animal studies have found high chromium levels in kidneys, lungs, and spleens. Chromate is reduced to chromic chromium inside the body. Excretion is primarily through the urine.

The studies reviewed identified both acute and chronic toxicity from exposure to chromium. The acute effects of chromium are rarely seen; specific toxic effects include gastrointestinal bleeding, fluid loss, and death from shock. A few cases of liver and kidney toxicity have been reported. Chronic toxicity is most commonly reported from industrial exposure to chromate or to mixed chromate and chromic forms of chromium. Exposure is primarily respiratory and dermal, with effects generally at the site of exposure. Typical symptoms include allergic contact dermatitis, skin ulcers, rhinitis, nasal membrane inflammation and ulceration, nasal septum perforation, tooth erosion and discoloration, pulmonary congestion, and pulmonary edema. Some cases also report liver and kidney lesions. Lung tumors are quite common in chromate-exposed workers; rates are highest among heavy cigarette smokers. There are some reports of cancers at other sites also. There is no evidence of carcinogenicity for chromic chromium. A few studies have reported reproductive toxicity to animals, but the doses were quite large.

Chlordane

Chlordane is moderately toxic through all routes of exposure and may pose significant health risks in the form of liver effects in chronically exposed humans. Based on sufficient evidence from studies in which liver tumors were induced in various strains of mice and rats, chlordane is classified as a probable human carcinogen via the ingestion and inhalation routes of exposure. Acute exposure to chlordane produces effects that include hyperexcitability, convulsions, depression, and death. Chlordane also produces adverse reproductive effects in mice. Chronic exposure may produce hematologic and neurotoxic effects.

Lindane (gamma-BHC)

The alpha, beta, and gamma (lindane) isomers of hexachlorocyclohexane have all been shown to cause liver tumors in laboratory animals. Classified as a possible human carcinogen, studies of gamma-BHC have shown development of benign hepatomas, hepatocellular carcinomas, or liver tumors in mice fed either beta- or gamma-BHC. Exposure to gamma-BHC has been associated with embryo mortality in rodents, and the development of aplastic anemia in humans.

Tetrachloroethene (TCE)

TCE compound is metabolized in the liver to a variety of metabolites, at least some of which are responsible for much of trichloroethene's toxicity. Metabolites are excreted primarily in the urine. TCE interacts with a number of other chemicals, including ethanol, generally increasing the severity of effects of both compounds. Chronic dosing produces liver and kidney lesions as well as a peripheral neuritis. The chemical was found to be carcinogenic in some animal tests, but no human data are available. There is no evidence of reproductive toxicity in the few tests available.

Hydrocarbons - Petroleum Distillates

Hydrocarbons or petroleum distillates include motor oil, gasoline, kerosene, red seal oil and furniture polish, and are found in combination with other chemicals as a vehicle or solvent. The toxicity of hydrocarbons is generally inversely proportional to the agent's viscosity, with products having high viscosity such as heavy greases or oils considered to have only limited toxicity. Information on decane and octane are presented below.

Decane

Decane is a component of gasoline. Acute exposure to decane may cause tumors. Decane acts as a simple asphyxiant. Studies have shown that TD_{L0} (minimum toxic dose) for mice via skin is 25 g/kg/year; and LC_{50} (concentration resulting in 50 percent mortality) via inhalation is 72,300 mg/m³ per 2 hours.

Octane

Octane is an aliphatic hydrocarbon and a flammable liquid that occurs in natural gas and crude oil. It is used as a solvent and serves as an important chemical agent in the petroleum industry.

Octane can be toxic if taken orally. Ingestion of high concentrations of octane can cause narcotic effects on humans. If this compound is aspirated into the lungs, it may cause rapid death due to cardiac arrest, respiratory paralysis, and asphyxia. Dermal exposure for 5 hours to undiluted octane resulted in blister formation but no anesthesia; 1 hour caused a diffuse burning sensation throughout. Quantitation of risk was not possible because of inadequate data.

5.0 RISK CHARACTERIZATION

In this section, risks associated with each current and future land use exposure pathway described in Section 3.0 are quantified and evaluated for individual chemicals, for multiple chemicals within specific exposure pathways, and across multiple exposure pathways, as appropriate. Carcinogenic effects are evaluated for average lifetime exposures; noncarcinogenic effects are evaluated for long-term (chronic) exposures. Subchronic noncarcinogenic effects are also evaluated for future short-term on-site workers. Risks under current land use conditions are evaluated first, followed by risks under future land use conditions. The section concludes with a discussion of the uncertainties involved in risk characterization.

5.1 RISK CHARACTERIZATION METHODOLOGY

The methodologies used to characterize carcinogenic and noncarcinogenic risks are discussed separately below.

5.1.1 Carcinogenic Risks

For a carcinogen, a risk estimate represents the incremental probability that an individual will develop cancer over a lifetime as a result of exposure to that carcinogen (EPA, 1989b). These are termed "excess lifetime cancer risks" and are calculated using Equation 5-1:

$$\text{Upper-bound excess lifetime cancer risk (risk)} = \text{LADI} \times \text{SF} \quad (5-1)$$

where

$$\begin{array}{ll} \text{LADI} & = \text{Lifetime average daily intake (mg/kg/day)} \\ \text{SF} & = \text{Slope factor (mg/kg/day)}^{-1} \end{array}$$

Risk is expressed as a probability. For example, 1E-06 translates to one additional cancer in an exposed population of one million. The SF in almost all cases represents an upper 95th percent confidence limit of the probability of a carcinogenic response, based on experimental animal data used in a multistage model. Therefore, the resulting risk estimate represents an upper-bound estimate of the carcinogenic risk; the actual risk will probably not exceed the estimate and is likely to be lower.

As indicated on Tables 4-3 and 4-4, carcinogenic risks in this assessment are evaluated for chemicals with weight-of-evidence classifications of A, B1, B2, and C. Most available SFs have been derived from experiments in which the route of exposure was ingestion. The resulting oral SFs relate to the

amount of substance administered per unit of time and unit of body weight. When dermal routes of exposure are considered, chronic daily intake (CDI) is expressed as absorbed rather than administered doses. To estimate carcinogenic risks for dermal routes of exposure, EPA (1989b) recommends that SFs be adjusted to account for oral absorption efficiency. As noted in the exposure discussion in Section 3.0, these adjustments require specific knowledge of the tests used to develop toxicity values for each contaminant. Since this information is not readily available for all contaminants considered in this assessment, toxicity values were not adjusted. This could result in an underestimation of actual risks, since the toxic effects observed in testing may have resulted from an absorbed dose that is smaller than the known administered dose. However, because of the high degree of uncertainty involved in estimating risks from dermal exposure to contaminants and the conservative nature of the assumptions involved, the risks estimated for dermal exposures are more likely to overestimate the actual risks.

According to the revised NCP (EPA, 1990b), carcinogenic risks from exposures at a Superfund site after remediation may range from 1E-04 (one cancer in an exposed population of ten thousand) to 1E-06 (one cancer in an exposed population of one million). A risk level greater than 1E-04 is considered to present a significant risk, and a level less than 1E-06 is considered insignificant. Risk levels between 1E-04 and 1E-06 are within the target range. The terms "significant" and "insignificant" are not meant to imply acceptability; however, they help put the numerical estimates developed in this risk assessment into context. In general, a potential upper-bound excess lifetime cancer risk of 1E-06 is used by EPA as a point of departure or a benchmark.

Within a given exposure pathway, individuals may be exposed to more than one substance. To estimate the overall carcinogenic potential for each exposure pathway, PRC followed the procedures outlined in *Guidelines for the Health Risk Assessment of Chemical Mixtures* (EPA, 1986). The total upper-bound excess lifetime cancer risk for each exposure pathway is estimated using Equation 5-2:

$$\text{Risk}_T = \text{Risk}_1 + \text{risk}_2 + \dots + \text{risk}_i \quad (5-2)$$

where

$$\begin{aligned} \text{Risk}_T &= \text{Total cancer risk for a given exposure pathway} \\ \text{Risk}_i &= \text{Risk estimate for the } i^{\text{th}} \text{ substance} \end{aligned}$$

The risk summation methodology is based on two primary assumptions: (1) intakes of individual substances are small, and (2) the independent action of each substance is summed (no synergistic or antagonistic chemical interactions exist, and each substance causes the same effect--cancer). To the extent that these assumptions are not valid, the estimated total risk may overestimate or underestimate the actual risk.

Finally, at particular exposure points, receptors may be exposed via a number of contaminant exposure pathways. For example, under RME future land use conditions, receptors may be exposed to groundwater via a private well, to ambient air via inhalation, and to surface soil via incidental ingestion and dermal contact. The total exposure for a receptor equals the sum of the exposures via the various exposure pathways to which the receptor is exposed at a particular exposure point. The total incremental carcinogenic risk posed to a receptor via a combination of pathways is calculated using Equation 5-3:

$$\begin{aligned} \text{Total exposure point cancer Risk}_T &= \text{Risk (exposure pathway}_1) + \\ &\quad \text{Risk (exposure pathway}_2) + \dots + \\ &\quad \text{Risk (exposure pathway}_i) \end{aligned} \quad (5-3)$$

where:

Risk (exposure pathway_T) = risk from all exposure pathways

Risk (exposure pathway_i) = risk from the *i*th exposure pathway.

Chemical-specific cancer risks are summarized in the tables in Appendix J. The nature, development, and risks of each exposure pathway combination are discussed in Sections 5.2 and 5.3.

5.1.2 Noncarcinogenic Risks

For noncarcinogens, the potential for individuals to develop noncancer effects is evaluated by comparing an exposure dose developed over a specific exposure period to an RfD developed over a similar exposure period. This comparison takes the form of a ratio called a hazard quotient (HQ), and is expressed in Equation 5-4:

$$\text{HQ} = \text{E} / \text{RfD} \quad (5-4)$$

where

HQ	=	Hazard quotient
E	=	Chronic exposure (or intake)
RfD	=	Reference dose

ED and RfD are expressed in the same units and represent the same exposure period.

For most compounds, the RfD is expressed as an administered dose. Hazard quotient calculations are based on the assumption that both the RfD and exposure dose are expressed as an administered dose. Exposure doses for dermal routes of exposure are expressed as absorbed doses. As noted in

Section 5.1.1, toxicity values are not adjusted to reflect absorption and, therefore, hazard quotients could be underestimated. However, based on the conservative nature of the assumptions involved in the exposure and risk assessments, hazard quotients for dermal pathways are more likely to overestimate actual risks.

An HQ exceeding 1 indicates the potential for noncarcinogenic health effects. The sum of individual HQs associated with the same target organ (described below) may exceed 1 even if no single HQ exceeds 1.

In this risk assessment, exposure doses are developed and evaluated for chronic exposure periods for three age groups: children ages 1 to 6 (that is, for residential exposure), young adults ages 7 to 15 (that is, for recreational exposure), and adults 18 years or older. Thus, exposure-period durations are 6 years, 9 years, and 30 years, respectively. Thirty years corresponds to the period of time during which a person is considered to be exposed to a contaminant, assuming a 70-year life. Thirty-year exposure encompasses either 30 years of an adult life (that is, 18 years and older) or 30 years of combined child and adult exposure periods (for example, 6 years and 24 years, respectively). Residents are assumed to live at a given location for 30 years (the national average upper-bound time at one residence (EPA, 1989b)). Therefore, a chronic exposure is developed as appropriate for each age group. This approach assumes exposure at the estimated frequency for the length of each age group's exposure period. Each chronic exposure is evaluated using chronic RfDs.

Short-term future workers are also considered in this assessment. As noted in Section 3.4.3, the exposure period is estimated at 50 days. For this scenario, the subchronic exposure period is evaluated using subchronic RfDs.

As with carcinogenic substances, within a given exposure pathway, individuals may be exposed to multiple substances with noncarcinogenic health effects. To estimate the overall noncarcinogenic potential for each exposure pathway, PRC followed the procedures outlined in *Guidelines for the Health Risk Assessment of Chemical Mixtures* (EPA, 1986). The total noncarcinogenic risk for each exposure pathway is estimated using Equation 5-5:

$$\text{Hazard Index (HI)} = E_1 / \text{RfD}_1 + E_2 / \text{RfD}_2 + \dots + E_i / \text{RfD}_i \quad (5-5)$$

where

E_i = Exposure dose (or intake) for the i^{th} substance: for subchronic exposure periods, E_i is calculated as a 50-day dose; for a chronic exposure period, E_i is calculated as a chronic daily intake averaged over the length of each age group. In each case, E_i is presented in mg/kg/day.

$$RfD_i = \text{Maximum acceptable level (AL) for the } i^{\text{th}} \text{ substance} \\ \text{[for the purposes of this risk assessment, AL equals the} \\ \text{RfD for the } i^{\text{th}} \text{ substance (EPA, 1989b)].}$$

This summation methodology assumes that the various substances to which a receptor is exposed cause the same health effect by the same mechanism. If this assumption is incorrect, the estimated total exposure point HI may overestimate the total noncarcinogenic risk for a given exposure pathway. This methodology also assumes that when the mechanism of interaction is unknown, the assumption of adaptivity predicts reasonably well the toxicities of mixtures. If this assumption is incorrect, the HI may overestimate or underestimate the noncarcinogenic risk.

As discussed earlier for carcinogenic effects, exposure pathway combinations are developed for receptors both on and off site. The total noncarcinogenic risk posed to a receptor via a combination of pathways may be calculated using Equation 5-6:

$$\begin{aligned} \text{Total exposure point HI} &= \text{HI (Exposure pathway}_1\text{)} + \\ &\quad \text{HI (Exposure pathway}_2\text{)} + \dots + \\ &\quad \text{HI (Exposure pathway}_i\text{)} \end{aligned} \quad (5-6)$$

Chemical-specific hazard quotients are summarized in tables contained in Appendix J. Hazard quotients and hazard indices are discussed for specific pathways in Sections 5.2 and 5.3.

5.2 CURRENT LAND USE CONDITIONS

Risks under current land use conditions associated with each of the exposure pathways described in Section 3.0 are discussed below and summarized in table format. Current land use conditions considered in the risk assessment are recreational, trespassing, and off-site residential scenarios.

5.2.1 Recreational Uses

Whole- and partial-body exposure to contaminants in surface water are assessed for this exposure scenario. Predicted cancer risks are 10^{-9} or less; pyrene is the only carcinogenic compound detected in surface water. Predicted hazard quotients are 10^{-4} or less. Predicted combined cancer risks to carcinogenic polycyclic aromatic hydrocarbons (PAHs) detected in sediment samples in the drainage ditch are in the 10^{-7} range, with individual compounds presenting 10^{-8} or less cancer risks, except for BAP at 1×10^{-7} . Although the predicted hazard index for sediments is 2×10^{-5} , all chemical-specific hazard quotients are 10^{-6} or less. As noted, whole body risks to a recreational swimmer in the Des Plaines River or a person coming in contact with sediments were determined from the data

obtained from samples collected in the drainage ditch. Based on the low risks predicted for sediments in the ditch adjacent to the site, actual risks to recreational receptors in the Des Plaines River are also expected to be insignificant.

Contaminant-specific excess cancer risks and hazard indices for the recreational pathway are presented in Appendix J, Tables J-1 through J-4, and are summarized in Table 5-1.

5.2.2 Trespassers

Soil ingestion and dermal contact pathways were considered for a potential trespasser on the Lenz Oil site. An infrequent exposure period of 10 events per year, each 1 hour in duration, was assumed for this pathway. Sample results from nonexcavated site area B were used to determine risks to a trespasser because predicted residential scenario risks for area B are higher than for area A. Predicted soil ingestion cancer risks for a trespasser are 10^{-8} , with Arochlor-1242, and BAP resulting in 10^{-8} cancer risks. Cancer risks for these compounds are similar to those for dermal contact with soils, with arochlor-1242, arochlor-1254, and several carcinogenic PAHs contributing 10^{-8} cancer risks. All hazard indices are below 10^{-4} , which is not a significant health threat.

On-site particulate air emissions are predicted using the Cowherd model (see Appendix E). Risks from particulate air emissions predicted for the future on-site residential scenario in Section 5.3 are at 10^{-8} or less, with the exception of cadmium, which presents an excess cancer risk of 1×10^{-7} . Risks to trespassers would be significantly lower since the exposure duration is much shorter; therefore, risks from particulate air emissions are not assessed for a trespasser. Organic compound air emissions are predicted for the site area using an EPA dispersion model, SCREEN (see Appendix F). Concentrations potentially released from areas A and B are predicted for the nearest residence. Since this residence is located directly adjacent to the site, an assumption is made that the predicted concentrations are also representative of those potentially occurring on the site. Potential area B emissions are used to assess the trespasser scenario because they result in higher risks than those predicted for area A. An overall cancer risk of 10^{-4} is predicted for this pathway, with benzo(b)fluoranthene contributing a cancer risk in the 10^{-4} range, benzo(k)fluoranthene contributing a risk in the 10^{-6} range, and TCE, tetrachloroethylene (PCE), other carcinogenic PAHs, and alpha and gamma chlordane isomers contributing risks in the 10^{-7} range. A hazard quotient of 1×10^{-3} is predicted for 1,2-dichloropropane. As noted in Appendix F, the predicted air concentrations and resulting risks are likely to be overly conservative due to modeling assumptions and a poor characterization of surface soil contaminant concentrations.

TABLE 5-1
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES

Current Land Use Conditions - Recreational

		Risk			Hazard Indices		
Medium	Exposure Pathway	Child/Young Adult	Adult	Adult/Child Combined	Child/Young Adult	Adult	Adult/Child Combined
Surface water drainage ditch	Dermal contact partial body	8×10^{11}	7×10^{11}	2×10^{10}	6.3×10^{-6}	2×10^{-6}	1.2×10^{-5}
Surface water drainage ditch-(assume conditions in Des Plaines River)	Dermal contact whole body	2×10^{10}	5×10^{10}	7×10^{10}	1.7×10^{-5}	3.5×10^{-5}	5.2×10^{-5}
Surface water drainage ditch	Ingestion	2×10^9	3×10^9	5×10^9	1.7×10^{-4}	2.1×10^{-4}	3.8×10^{-4}
Sediment drainage ditch	Dermal	1×10^7	7×10^6	2×10^7	2.3×10^{-4}	1.5×10^{-4}	3.8×10^{-5}

Chemical-specific excess cancer risks and hazard indices for the trespasser pathway are presented Appendix J, Tables J-5 through J-7, and are summarized in Table 5-2.

5.2.3 Current Residents

Current residents living adjacent to the site are also considered in this risk assessment, and their exposures are considered similar to the inhalation exposures predicted for future nearby residents. Organic compound air emissions released from areas A and B are predicted at the nearest residential area to the site. As noted above, conservative predictions of air concentrations result in significant cancer risk predictions. For a residential receptor exposed over a 30-year period, cancer risks of 4×10^{-2} [benzo(b)fluoranthene], 10^{-3} [benzo(k)fluoranthene], 10^{-4} (1,1,2,2-tetrachloroethane, carcinogenic PAHs, Gamma-BHC, and the chlordane isomers) are predicted. Hazard quotients predicted are all less than 0.1. Predicted emissions from area B resulted in approximately one order of magnitude greater carcinogenic risk than those reported for area A, while a noncarcinogenic risk of 2×10^{-1} driven mainly by carbon disulfide predicted from Area A is one order of magnitude greater than that in Area B. These risks are likely to be overestimated; air monitoring or more sophisticated and precise air modeling may result in lower predictions of risk.

As mentioned above, the current nearby residential inhalation exposures are expected to be similar to future nearby residents. Chemical-specific excess cancer risks and hazard indices resulting from inhalation exposures predicted for future nearby residents are presented in Appendix J, Tables J-10 and J-14, and are summarized in Table 5-3. For comparison, excess cancer risks and hazard indices based on central tendency exposure assumptions are summarized in Table 5-9 in Section 5.6.4. These risks are all within one order of magnitude less than the risks summarized in Table 5-3. Cancer risks and hazard quotients for individual contaminants are included in Appendix J.

5.3 FUTURE LAND USE CONDITIONS

Future land uses considered for the site include residential and short-term occupational exposure.

5.3.1 Short-term Workers

It is assumed that homes could be constructed on the site which would result in an initial short-term exposure to construction workers building the homes. The assumption is made that no site remediation has occurred and that contaminant levels are the same as those measured during Phases 1 and 2 of the RI. The exposure period is estimated to be 10 weeks, with 8 hours of exposure for 5 days each week. Subchronic reference doses are used when available to determine hazard quotients.

TABLE 5-2
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES

Current Land Use Conditions - Trespasser^a

		Risk			Hazard Indices		
Medium	Exposure Pathway	Child	Adult	Adult/Child Combined	Child/Young Adult	Adult	Adult/Child Combined
Soil Area B	Dermal Contact	2×10^{-7}	4×10^{-7}	6×10^{-7}	2.8×10^{-3}	5.7×10^{-3}	8.5×10^{-3}
Soil Area B	Ingestion	7×10^{-8}	8×10^{-8}	1×10^{-7}	3.0×10^{-3}	4.2×10^{-3}	7.2×10^{-3}
Air-organic compound emissions, Area B	Inhalation	—	1×10^{-4}	—	—	1.1×10^{-3}	—

^a Inhalation considered for adult receptor only, over 30 year exposure

TABLE 5-3
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
Current Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk	Hazard Indices
Air-organic compound emissions, Area A	Inhalation adult	9×10^{-3}	2.4×10^{-1}
Air-Organic compound emissions, Area B	Inhalation adult	5×10^{-2}	6.8×10^{-2}

^a Inhalation considered for adult receptor only, over 30 year exposure

Risks to workers are predicted using the soil contaminants measured in area B, which was selected because risks predicted for longer-term residential exposure are higher than those resulting from exposure to soils in area A. Thus, the more conservative risk estimates are determined. Cancer risks predicted for ingestion of soil during construction activities are all below 1×10^{-8} , except for arochlor-1242 and BAP, which are in the 10^{-8} range. All chemical-specific hazard quotients are less than 10^{-2} , except for chromium at 1×10^{-2} . Dermal contact with soils results in cancer risks of less than 10^{-8} , except for arochlor-1242, at 1×10^{-8} . All hazard quotients are less than cadmium, which has a hazard quotient of 1×10^{-2} .

Inhalation risks to short-term workers are estimated from the dispersion modeling performed for area B soils. The modeling predicted potential concentrations of contaminants in the air at an adjacent residence. Since the nearest residence is located just over the site boundary, an assumption is made that the predicted concentrations are also representative of concentrations potentially occurring on the site. A cancer risk of 2×10^{-4} is predicted for benzo(b)fluoranthene. A cancer risk of 2×10^{-5} is predicted for benzo(k)fluoranthene. Cancer risks in the 10^{-6} range are predicted for alpha and gamma chlordane, and gamma-hexachlorocyclohexane (Gamma-BHC). A hazard quotient of 0.05 is predicted for 1,2-dichloropropane.

The predicted airborne contaminant concentrations and risks are conservative and potentially overpredict actual risks. However, the modeling did not include consideration of excavation of soils during construction activities, which could result in more significant concentrations of contaminants being released to the air in particulate or organic vapor form. While such emissions are short-term, they may result in higher risks to a construction worker.

The chemical-specific excess cancer risks and hazard indices for the future short-term workers pathway are presented in Appendix J, Tables J-29 through J-31, and are summarized in Table 5-4.

5.3.2 Future Residents

Both areas A and B are considered in the future residential land use scenario. Combined risks to adults and children are determined for soil ingestion and dermal contact exposures. Risks to children ages 1 to 6 are also determined for soil ingestion and dermal contact. Risks resulting from inhalation of contaminants released from soil and ground water at the site are considered for adults. Risks resulting from ingestion of and dermal contact with groundwater are also determined for adults and children.

TABLE 5-4
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES

Future Land Use Conditions - Short-term worker^a

Medium	Exposure Pathway	Risk	Hazard Indices
Soil Area B	Dermal	1×10^{-7}	3.5×10^{-3}
Soil Area B	Ingestion	9×10^{-6}	2.0×10^{-2}
Air organic compound emissions	Inhalation	3×10^{-4}	4.5×10^{-1}

^a Inhalation considered for adult receptor only, over 30 year exposure

Soil ingestion in area B for both children and adults resulted in a total cancer risk of 1×10^{-5} , with the highest contributions from exposure to BAP (3×10^{-6}) and Arochlor - 1242 (1×10^{-6}). Cancer risks in the 10^{-7} range are predicted for arochlor-1260, arochlor-1254, DDD, DDE, and pyrene. Cancer risks in the 10^{-7} range are also predicted for carcinogenic PAHs. A hazard quotient of 3×10^{-3} is predicted for cadmium. Similar soil ingestion risks are predicted for area A, with the arochlor isomers and carcinogenic PAHs resulting in 10^{-6} and 10^{-7} risks, respectively. Soil ingestion risks for children ages 1 to 6 range only from 10^{-6} to 10^{-7} for arochlor isomers and carcinogenic PAHs.

Dermal contact with soil in area B for both children and adults resulted in a total cancer risk of 1×10^{-5} , with cancer risks in the 10^{-6} to 10^{-7} range for the arochlor isomers, DDE, DDT, and carcinogenic PAHs. The most significant hazard quotient is 2×10^{-4} for aldrin. Soil dermal contact cancer risks in area A are similar, with risks in the 10^{-6} and 10^{-7} ranges for arochlor isomers and carcinogenic PAHs. The most significant hazard quotient for area A is 3×10^{-4} for cadmium. Dermal contact cancer risks for children ages 1 to 6 in area B are the same approximate magnitude as those predicted for soil ingestion.

On-site particulate air emissions are predicted using the Cowherd model (see Appendix E). The cancer risks from particulate air emissions from areas A and B are 10^{-8} or less. Organic compound air emissions are predicted for the site area using an EPA dispersion model, SCREEN (see appendix F). Concentrations potentially released from areas A and B are predicted for the nearest residence. Air modeling was performed using both surface soil and soil profiles (that is, combined surface and subsurface sample data) RME concentrations. The model assumes that RME concentrations for both surface soil and soil profile samples are present at 1 foot below the surface. This is a conservative assumption for the soil profile sample data, considering that soil samples were collected from the surface to a depth of approximately 9 feet.

Since the nearest residence is located just over the site boundary, an assumption is made that the predicted concentrations are also representative of those potentially occurring on the site. Contaminant concentrations could be higher, but based on the conservative nature of the model, they are more likely to be lower.

The risks to future on-site residents are the same as those predicted for the adjacent residence. For a residential receptor exposed over a 30-year period, predicted cancer risks are 4×10^{-2} [benzo(b)fluoranthene], 3×10^{-3} [benzo(k)fluoranthene], and in the 10^{-4} range for 2 carcinogenic PAHs, Gamma-BHC, and the chlordane isomers. A hazard quotient of 0.06 was predicted for trans-1,3-dichloropropene. Predicted emissions from area B resulted in approximately one-half order of magnitude greater risk than those reported for area A. These risks are likely to be

overestimated; air concentrations determined from air monitoring or more sophisticated and precise air modeling may result in lower predictions of risk.

No current receptors exist for contaminants in groundwater from either the upper or lower portions of the aquifer. The only receptors evaluated for exposure to groundwater at the Lenz Oil site are future residents. The groundwater was evaluated in four separate locations: the on-site upper portion of the aquifer; the on-site lower portion of the aquifer; the off-site upper portion of the aquifer; and the off-site lower portion of the aquifer. Three separate pathways were evaluated: ingestion of groundwater; dermal exposure to contaminants in groundwater during showering; and inhalation of volatile organic compounds in groundwater during showering.

Total carcinogenic risk from exposure to contaminants in the on-site upper portion of the aquifer are 4×10^{-2} for adults and 2×10^{-2} for children. Most of this risk is contributed by dermal exposure to and ingestion of PCBs. The risk from inhalation of volatiles is three orders of magnitude less (4×10^{-5}), and is contributed primarily by 1,1-dichloroethene, chloroform, and benzene. The total hazard index for exposure to groundwater in the on-site upper portion of the aquifer is 1.2 for adults and 0.62 for children. Naphthalene, ethylbenzene and xylenes contributes most of the hazard resulting from ingestion and dermal exposure. The hazard index for inhalation of volatiles is 7×10^{-3} , and is contributed mostly by ethyl benzene and toluene.

Total carcinogenic risk from exposure to contaminants in the on-site lower portion of the aquifer are 2×10^{-6} for adults and 9×10^{-7} for children. All of the risk is contributed by exposure to benzene. The total hazard index for exposure to contaminants in the on-site lower portion of the aquifer is 7×10^{-4} for adults and 3×10^{-4} for children. The noncarcinogenic risk is contributed solely by exposure to toluene, diethylphthalate and di-n-butyl phthalate. The total carcinogenic risk resulting from inhalation was 4×10^{-7} , resulting solely from exposure to benzene.

Total carcinogenic risks from exposure to contaminants in the off-site upper portion of the aquifer were 4×10^{-4} for adults and 2×10^{-4} for children, from ingestion of and dermal contact with 1,1-dichloroethene, vinyl chloride, 1,2-dichloroethene, and tetrachloroethene. The total hazard index for the aquifer was 5×10^{-2} for children and 9×10^{-2} for adults. No individual chemicals contributed a significant portion of the total overall hazard index.

Total carcinogenic risk from exposure to contaminants in the off-site lower portion of the aquifer were 2×10^{-4} for children, and 3×10^{-4} for adults, contributed solely by exposure to 1,1-dichloroethene and vinyl chloride. The total hazard index was 0.1 for children, and 0.3 for adults, primarily from exposure to chromium and 1,2-dichloroethene.

Chemical-specific excess cancer risks and hazard indices for the future residential pathway are presented in Appendix J, Table J-8 through J-28, and are summarized in Table 5-5. For comparison, excess cancer risks and hazard indices based on central tendency exposure assumptions are summarized in Table 5-10 in Section 5.6.4. These risks, with one exception, are all within one order of a magnitude less than those the risks summarized in Table 5-5. The carcinogenic risks associated with dermal contact with soil are slightly greater than one order of magnitude less than the risks presented in Table 5-5.

5.4 COMBINED PATHWAY CANCER RISKS AND HAZARD INDICES

Risks for specific exposure pathways are combined to determine potential total excess cancer risks and hazard indices for receptor populations. Specific receptors and the pathways to which they are potentially exposed are described in the following sections and summarized in Tables 5-6 and 5-7.

5.4.1 Recreational Pathways

The recreational receptor is potentially exposed to contaminated surface water and sediment. As previously discussed, whole- and partial-body exposure is considered for dermal contact with surface water. The whole-body exposure is assessed to estimate worst-case risks to a potential receptor in the Des Plaines River. Surface water ingestion and dermal contact with sediments are also considered. The combined cancer risks for this receptor total 2×10^{-7} and the combined hazard indices total 4×10^{-5} .

5.4.2 Trespasser Pathway

The trespasser receptor is assumed to be infrequently exposed to on-site contaminants. This receptor is hypothetically an area resident who enters the site for a 1-hour period up to 10 times a year. Soil ingestion and dermal contact exposure are assumed, as well as inhalation of organic compounds released from the soil. The combined cancer risks and hazard indices for this receptor total 1×10^{-4} and 1×10^{-3} , respectively. Inhalation exposure is the pathway of primary concern.

5.4.3 Current Adjacent Resident Pathway

This receptor lives adjacent to the site and is assumed to reside at this location for a 30-year period. The receptor may inhale organic compound emissions released from the site soil and come in contact with contaminated soils on the site if trespassing. The combined cancer risks and hazard indices for this receptor total 5×10^{-2} and 8×10^{-2} respectively. Inhalation exposure is the pathway of primary concern.

TABLE 5-5
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
Future Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk			Hazard Indices		
		Child	Adult	Adult/Child Combined	Child/Young Adult	Adult	Adult/Child Combined
Soil Area B	Dermal contact	4×10^{-4}	8×10^{-4}	1×10^{-3}	5.6×10^{-4}	1.2×10^{-3}	1.7×10^{-3}
Soil Area B	Ingestion	8×10^{-4}	3×10^{-4}	1×10^{-3}	2.7×10^{-3}	1.5×10^{-3}	4.8×10^{-3}
Air-particulate emissions, Area B	Inhalation, adult only	—	2×10^{-4}	—	—	6.9×10^{-9}	—
Air-organic compound emissions, Area B	Inhalation, adult only	—	5×10^{-3}	—	—	7.8×10^{-2}	—
Soil Area A	Dermal contact	5×10^{-4}	1×10^{-3}	2×10^{-3}	5.8×10^{-4}	1.3×10^{-3}	1.9×10^{-3}
Soil Area A	Ingestion	1×10^{-3}	4×10^{-4}	2×10^{-3}	8.4×10^{-3}	3.6×10^{-3}	1.2×10^{-2}

^a Inhalation considered for adult receptor only, over 30 year exposure

TABLE 5-5 (continued)
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES

Future Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk			Hazard Indices		
		Child	Adult	Adult/Child Combined	Child/Young Adult	Adult	Adult/Child Combined
Air particle emissions Area A	Inhalation - adult only	—	2×10^7	—	—	5.0×10^9	—
Air organic compound emissions area A	Inhalation - adult only	—	9×10^3	—	—	2.0×10^1	—
Soil Area B	Dermal contact-children ages 1-6 only	4×10^4	—	—	2.8×10^3	—	—
Soil Area B	Ingestion-children ages 1-6 only	8×10^4	—	—	2×10^2	—	—

^a Inhalation considered for adult receptor only, over 30 years exposure

TABLE 5-5 (continued)
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
Future Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk			Hazard Indices		
		Child Adult	Adult	Total	Child/Young Adult	Adult	Total
On-site upper aquifer	Ingestion	9×10^3	1×10^3	2×10^3	5.8×10^{-1}	1.1×10^{-1}	1.7×10^{-1}
On-site upper aquifer	Dermal contact	1×10^3	3×10^{-2}	4×10^{-2}	3.6×10^{-3}	7.8×10^{-3}	1.1×10^{-4}
On-site upper aquifer	Inhalation of volatiles while showering-adult only	—	4×10^3	—	—	6.9×10^3	—
On-site lower aquifer	Ingestion	9×10^7	2×10^6	3×10^6	3.1×10^{-4}	6.6×10^{-4}	9.7×10^{-4}
On-site lower aquifer	Dermal contact	1×10^6	2×10^8	3×10^8	2.3×10^{-3}	2.3×10^{-7}	2.3×10^{-3}
Off-site upper aquifer	Ingestion	2×10^4	4×10^4	6×10^4	5.0×10^{-3}	8.6×10^{-3}	1.4×10^{-1}
Off-site upper aquifer	Dermal contact	4×10^4	8×10^4	1×10^5	1.3×10^{-3}	2.9×10^{-3}	4.3×10^{-3}
Off-site upper aquifer	Inhalation of volatiles while showering-adult only	—	4×10^3	—	—	—	—
Off-site lower aquifer	Ingestion	2×10^4	3×10^4	5×10^4	1.4×10^{-1}	2.9×10^{-1}	4.3×10^{-1}
Off-site lower aquifer	Dermal contact	3×10^4	7×10^4	1×10^5	8.3×10^{-3}	3.6×10^{-3}	2.6×10^{-3}

^a Inhalation considered for adult receptor only, over 30 year exposure

TABLE 5-6
SUMMARIES OF EXCESS CANCER RISKS

Exposure Pathway	Current Recreational		Current Trespasser	Current Adjacent Resident	Future Residential - On Site		Future Resident Adjacent to Site	Future Short-Term Worker
	Drainage Ditch	Assumed Conditions - Des Plaines River			Child/Adult Combined 30 Year Exposure	Child 6 Year Exposure		
Surface water dermal contact	2×10^{10}	7×10^{10}						
Surface water ingestion	5×10^9	5×10^9						
Sediment dermal contact	2×10^7	2×10^7						
Soil dermal contact Area B			6×10^7	3×10^7	1×10^3	4×10^4	3×10^4	1×10^7
Soil ingestion Area B			1×10^7	8×10^7	1×10^3	8×10^4	8×10^7	9×10^8
Inhalation particulate emissions Area B				4×10^8	2×10^4		4×10^8	
Inhalation organic compound emissions Area B			1×10^4	5×10^3	5×10^2		5×10^2	3×10^4
Groundwater ingestion					2×10^2		6×10^4	
Groundwater dermal contact					4×10^2		1×10^3	
Groundwater inhalation of volatiles while showering					4×10^3		4×10^3	
TOTAL EXCESS CANCER RISK	2×10^7	2×10^7	1×10^4	5×10^2	1×10^1	1×10^3	9×10^2	3×10^4

TABLE 5-7
SUMMARIES OF HAZARD INDICES

Exposure Pathway	Current Recreational		Current Trespasser	Current Adjacent Resident	Future Residential - On Site		Future Resident Adjacent to Site	Future Short-Term Worker
	Drainage Ditch	Assumed Conditions - Des Plaines River			Child/Adult Combined 30 Year Exposure	Child 6 Year Exposure		
Surface water dermal contact	1.2×10^{-5}	5.2×10^{-5}						
Surface water ingestion	3.8×10^{-4}	3.8×10^{-4}						
Sediment dermal contact	3.8×10^{-5}	3.8×10^{-5}						
Soil dermal contact Area B			8.5×10^{-5}	8×10^{-5}	1.7×10^{-5}	2.8×10^{-5}	8×10^{-5}	3.5×10^{-5}
Soil ingestion Area B			7.2×10^{-5}	5×10^{-5}	4.8×10^{-5}	1.7×10^{-5}	5×10^{-5}	2.0×10^{-5}
Inhalation particulate emissions Area B				8×10^{-9}	6.9×10^{-9}		8×10^{-9}	
Inhalation organic compound emissions Area B			1.1×10^{-3}	7.8×10^{-2}	7.8×10^{-2}		7.8×10^{-2}	4.5×10^{-1}
Groundwater ingestion					1.7×10^{-9}		1.4×10^{-1}	
Groundwater dermal contact					1.1×10^{-1}		4.3×10^{-3}	
Groundwater inhalation of volatiles while showering					6.9×10^{-3}			
TOTAL HAZARD INDICES	4.3×10^{-4}	4.7×10^{-4}	1.3×10^{-3}	7.8×10^{-2}	1.9×10^{-9}	2.0×10^{-2}	2.2×10^{-1}	4.7×10^{-1}

5.4.4 Future On-Site Residential Pathways

This future residential receptor is assumed to reside on the site for 30 years. Pathways of concern are dermal contact and ingestion of soils, inhalation of particulate and organic compound emissions from area B, and on-site groundwater ingestion and dermal contact. Inhalation of volatile emissions while showering is also assumed. Combined adult and cancer risks and hazard indices total 1×10^{-1} and 1.9 respectively. The most significant risks result from the groundwater inhalation, ingestion, and dermal contact pathways, and inhalation of volatile organic compound emissions from the soil.

Risks resulting from dermal contact and ingestion of soils in area B are also combined for children ages 1 to 6. Combined cancer risks and hazard indices are 1×10^{-5} and 2×10^{-2} , respectively.

5.4.5 Future Off-Site Residential Pathways

This future residential receptor is assumed to reside adjacent to the site for 30 years. Pathways of concern are dermal contact and ingestion of soils during trespassing, inhalation of particulate and organic compound emissions from area B, and off-site groundwater ingestion and dermal contact. Inhalation of volatile emissions while showering is also assumed. Combined adult and children cancer risks and hazard indices total 9×10^{-2} and 2.2×10^{-1} respectively. The most significant risks result from inhalation of organic compounds and from the groundwater ingestion pathways.

5.4.6 Future Short-term Worker Pathway

The short-term worker receptor is assumed to be on site for construction and excavation activities for a 10-week period. Pathways evaluated include dermal contact and ingestion of soils and inhalation of organic compound emissions. Combined cancer risks and hazard indices for this receptor total 3×10^{-4} and 5×10^{-1} , respectively. Inhalation risks is the pathway of primary concern.

5.5 QUALITATIVE RISK ASSESSMENT

5.5.1 Chemicals Without Toxicity Values

Risks associated with certain contaminants detected at the site are not quantified because risk factors are not available. These contaminants include chemicals that are tentatively identified and chemicals that have been confirmed as present on the site based on qualified data. Tentatively identified compounds are discussed in Section 4.0. Compounds confirmed as present in site-related media are listed in Appendix J along with the contaminants for which quantitative risks were assessed. The

percentage of chemicals in each pathway that do not have toxicity values (that is, both cancer slope factors and RFDs) are reviewed. For the soil pathways, approximately 20 percent of the detected contaminants do not have toxicity values. For the inhalation pathways, up to 50 percent of the detected contaminants do not have toxicity values. For the groundwater pathways, up to 20 percent of the detected contaminants do not have toxicity values. The risks for each pathway are potentially underestimated by these percentages if an assumption is made that contaminants without toxicity values present risks comparable to those contaminants that do have toxicity values.

5.5.2 Exposure to Lead

This section presents a qualitative evaluation of lead toxicity (see Appendix H). The risk of health effects related to lead exposure varies according to the individual, depending on nutritional status, age, and total lead body burden from all sources. Women are generally more sensitive to the effects of lead in the blood system than men. Also, fetuses may be at particular risk.

EPA (1990) has determined that there may be no threshold for the adverse effects of lead, particularly for neurobehavioral effects in children. A concentration of lead as low as 1 mg/L in drinking water has been demonstrated to produce clinical lead poisoning (NLM, 1990). However, no lead concentrations significantly above background were detected in ground water at the site.

Lead has also been measured in surface and subsurface soils at the site. In particular, the RME lead concentrations are 353 and 499 parts per million in area B and area A, respectively.

The Center for Disease Control (CDC, 1985) has published guidance for lead concentrations in residential soils that the center associates with an acceptable level of risk. Specifically, CDC personnel concluded that adverse clinical and health effects (elevated blood lead levels) may result from exposure to lead levels in soils and dust at concentrations exceeding 500 to 1,000 mg/kg. Exposure to soils with lead concentrations less than 500 mg/kg is generally not expected to result in adverse health effects. Again, however, the risk of adverse health effects varies according to the individual.

5.6 UNCERTAINTIES IN RISK CHARACTERIZATION

Risk estimates calculated in this risk assessment are subject to varying degrees of uncertainty from a variety of sources. In contrast to the uncertainties involved in estimating exposure, the uncertainties inherent in risk characterization depend less on availability of site-specific information and more on availability and use of chemical-specific toxicity information. This section identifies

the most significant sources of uncertainty for the risk characterization and assesses the potential impact of the uncertainty.

The following sources of uncertainty are discussed:

- Risk factors
 - Extrapolations (related to species, exposure dose, and exposure period)
 - Adjustment of risk factors
 - Slope factors
 - Lack of risk factors
- Risk summations
- Exposure periods

Table 5-8 summarizes these sources of uncertainty and expresses the likely effect of each uncertainty on the estimated risks by indicating if the effect of the uncertainty will be to (1) overestimate the risk, (2) underestimate the risk, or (3) over- or underestimate the risk.

5.6.1 Risk Factors

Risk factors, such as SFs and RfDs, are used to characterize risks associated with estimated exposures. However, uncertainty is involved in development and use of risk factors. Four specific sources of uncertainty are discussed below.

5.6.1.1 Extrapolations

Risk factors (SFs and RfDs) used in evaluating human health risks are developed using extrapolations made for species, exposure dose, and exposure period. These are discussed below.

Most risk factors are based on animal test results. However, humans may differ from test animals in uptake, metabolism, distribution, and elimination of chemicals. Risk factors are generally developed under the assumption that a human is as sensitive to a chemical as the test animal, even though results for the most sensitive test species are generally used as the basis for the risk factors. An uncertainty factor (usually 10, but sometimes up to 1,000) is incorporated into the risk factor to account for any greater human sensitivity. To the extent that human beings are more or less

Table 5-8

AREAS OF UNCERTAINTY AND
EFFECTS ON RISK ESTIMATES

Area of Uncertainty	May Overestimate Exposure	May Underestimate Exposure	May Over-or Underestimate Exposure
<u>Risk Factors</u>			
<ul style="list-style-type: none"> Extrapolation <p>Most risk factors are extrapolated from animal test results. Extrapolations, which may be made for species, exposure dose, and exposure period, are generally conservative.</p>	X		
<ul style="list-style-type: none"> Adjustment of Oral Risk Factors <p>In order to characterize risks from dermal exposures, generally expressed as absorbed doses, EPA (1989b) recommends that oral risk factors be adjusted to account for oral absorption efficiency. These adjustments were not made.</p>			X
<ul style="list-style-type: none"> Slope Factors (SF) <p>SFs represent upper 95 percent confidence limit values; carcinogenic risks calculated using SFs generally represent upper-bound estimates.</p>	X		
<ul style="list-style-type: none"> Lack of Risk Factors <p>Risks from exposure to chemicals with no available chemical-specific or substitute risk factors cannot be quantitatively characterized.</p>		X	
<u>Risk Summations</u>			
<p>Risks from chemical mixtures are characterized by summing the individual chemical risks. This procedure assumes that chemicals have the same toxic end points and mechanisms of action and do not interact, either synergistically or antagonistically. These assumptions may be incorrect.</p>			X
<u>Exposure Periods</u>			
<p>Subchronic exposures are characterized by comparison to chronic risk factors if subchronic factors are not available. Evaluating exposures using risk factors based on longer exposure is conservative.</p>	X		
<p>Exposure periods during which receptors can be exposed to predicted ambient air contaminant concentrations are likely to be less than 30 years</p>	X		

sensitive than the test animals, results may under estimate or (more likely) overestimate the true risks to humans.

In the laboratory, test animals are usually exposed regularly for less than 2 years to high chemical doses. In contrast, humans are likely to be exposed to much lower chemical doses on a less regularly basis for widely varying exposure periods. Limited human data exist for many chemicals characterized as carcinogenic in this risk assessment. Most of the evidence used to characterize these chemicals as carcinogenic is from animal studies. To the extent that particular chemicals are ultimately shown *not* to be carcinogenic to humans, carcinogenic risks presented in this risk assessment may overestimate actual carcinogenic risks associated with the site.

However, many noncarcinogenic health effects may have thresholds, meaning that they are not observed under low-dose or infrequent exposure conditions. If actual human exposures are below chemical-specific thresholds, use of risk factors based on laboratory exposures may result in an overestimation of actual risks.

In general, risk factors are very conservative in order to protect human health. In the risk characterization, therefore, estimated risks may overestimate true risks.

5.6.1.2 Adjustment of Risk Factors

This risk assessment presents carcinogenic and noncarcinogenic risks for chemicals with available risk factors (RfDs and SFs). Most available risk factors are derived from experiments in which the route of exposure was ingestion. The resulting oral risk factors are related to the amount of substance administered per unit of time and unit of body weight. When dermal routes of exposure are considered, exposures are expressed as absorbed rather than administered doses. To estimate risks for dermal routes of exposure, it is recommended that risk factors also be expressed in terms of absorbed doses. As noted in Section 5.1.2, risk factors were not adjusted. Therefore, exposure may be underestimated.

However, estimating risks from dermal exposure involves making several additional assumptions that do not apply to risks from oral exposure. Therefore, the uncertainty associated with estimating dermal risks is greater. Because of the high degree of uncertainty involved in estimating risks from dermal exposure to chemicals and because of the conservative nature of the assumptions involved, risks estimated for dermal exposures are more likely to overestimate actual risks than estimations made for other exposure pathways.

5.6.1.3 Slope Factors

SFs represent the upper 95 percent confidence limit values, based on the linearized, multistage carcinogenesis model. The estimated carcinogenic risks calculated using SFs generally represent upper-bound estimates of the true risks. Therefore, the use of these SFs may result in an overestimation of the true risks. Specifically, true risks are unlikely to be greater than the estimated values, and are likely to be less.

5.6.1.4 Lack of Risk Factors

Uncertainty is introduced by the lack of risk factors for some chemicals for which appropriate substitutes are not available. In not evaluating the risks from potential exposures to these chemicals, true risks may be underestimated. The percentages of chemicals for which toxicity values are not available are noted in Section 5.5. Risks are potentially underestimated by these percentages if the assumption is made that the compounds without toxicity values present risks that are comparable to those contaminants that have toxicity values.

5.6.2 Risk Summations

Risks from chemical mixtures found at the Lenz Oil site are calculated by summing individual chemical risks. This procedure is recommended by EPA guidance (1986 and 1989b) and assumes that all chemicals have the same toxic endpoints and mechanisms of action. However, this assumption may be incorrect; chemicals may in fact have different toxic endpoints and mechanisms of action. Furthermore, chemicals in a mixture may act synergistically or antagonistically once they enter the human body. Little information is currently available on synergistic or antagonistic actions within chemical mixtures. Interactions between chemicals in a mixture may form new toxic components or may cause changes in the bioavailability of the existing chemicals. Summation of individual chemical risks within and across exposure pathways may overestimate or underestimate true risks.

5.6.3 Exposure Periods

Exposure periods over which exposure doses are calculated should be similar to exposure periods for risk factors used to assess risks associated with the exposure doses. For example, chronic exposure doses should be evaluated using chronic risk factors. For this risk assessment, subchronic exposure doses are evaluated using chronic risk factors when subchronic risks factors are not available. In addition, because of the lack of appropriate test data, subchronic RfDs for some

chemicals are the same as their chronic RfDs. Evaluating exposure doses using risk factors based on longer exposure periods is conservative and generally results in an overestimation of true risks.

Exposure periods for inhalation of predicted airborne contaminants are assumed to be 30 years for residential receptors. As previously noted, the air dispersion models are conservative and may overestimate contaminant concentrations in air. In addition, the period of time over which the predicted contaminant concentrations can be present in the ambient air is limited by the mass of the contaminants present in on-site soils. This period is likely to be significantly less than 30 years. As such, the risks determined for the ambient air inhalation pathways are likely to be overestimated.

5.6.4 Central Tendencies

The exposure scenarios presented in this RA follow current EPA guidance (EPA, 1989b) and use exposure factors to estimate the reasonable maximum exposure (RME) at the site. For comparison, Tables 5-9 and 5-10 present risks estimated based on less conservative (central tendency) exposure factors when available. Central tendency risks are evaluated only for pathways identified as significant in RME evaluation. All central tendency risks are within slightly over one order of magnitude (up to 20 times) less than RME risks calculated for the same pathways.

TABLE 5-9

SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
(Central Tendency)

Current Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk	Hazard Indices
Air-organic compound emissions, Area A	Inhalation adult	2×10^{-3}	1.4×10^{-1}
Air-Organic compound emissions, Area B	Inhalation adult	8×10^{-3}	4.0×10^{-2}

^a Inhalation considered for adult receptor only, over 30 year exposure

TABLE 5-10
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
(Central Tendency)
Future Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk			Hazard Indices		
		Child	Adult	Adult/Child Combined	Child/Young Adult	Adult	Adult/Child Combined
Soil Area B	Dermal contact	4×10^{-6}	1×10^{-6}	5×10^{-6}	5.6×10^{-4}	5.9×10^{-4}	1.2×10^{-3}
Soil Area B	Ingestion	8×10^{-6}	5×10^{-7}	9×10^{-6}	2.7×10^{-3}	7.2×10^{-4}	3.4×10^{-3}
Air-particulate emissions, Area B	Inhalation, adult only	—	3.1×10^{-7}	—	—	4.1×10^{-9}	—
Air-organic compound emissions, Area B	Inhalation, adult only	—	8×10^{-3}	—	—	4.6×10^{-2}	—
Soil Area A	Dermal contact	3×10^{-7}	6×10^{-7}	9×10^{-7}	3.4×10^{-4}	7.8×10^{-4}	1.1×10^{-3}
Soil Area A	Ingestion	2×10^{-6}	4×10^{-6}	2×10^{-6}	4.1×10^{-3}	1.8×10^{-3}	5.8×10^{-3}

^a Inhalation considered for adult receptor only, over 30 year exposure

TABLE 5-10 (continued)
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
(Central Tendency)
Future Land Use Conditions - Residential^a

		Risk			Hazard Indices		
Medium	Exposure Pathway	Child	Adult	Adult/Child Combined	Child/Young Adult	Adult	Adult/Child Combined
Air particle emissions Area A	Inhalation - adult only	--	3.2×10^{-4}	--	--	3.0×10^{-3}	--
Air organic compound emissions area A	Inhalation - adult only	--	1×10^{-3}	--	--	1.2×10^{-1}	--
Soil Area B	Dermal contact-children ages 1-6 only	4×10^{-6}	--	--	2.8×10^{-3}	--	--
Soil Area B	Ingestion-children ages 1-6 only	8×10^{-6}	--	--	2×10^{-2}	--	--

^a Inhalation considered for adult receptor only, over 30 years exposure

TABLE 5-10 (continued)
SUMMARIES OF EXCESS CANCER RISKS
AND HAZARD INDICES
(Central Tendency)
Future Land Use Conditions - Residential^a

Medium	Exposure Pathway	Risk			Hazard Indices		
		Child	Adult	Total	Child/Young Adult	Adult ^a	Total
On-site upper aquifer	Ingestion	9×10^3	2×10^2	1×10^2	5.8×10^{-1}	5.9×10^{-1}	1.2×10^{-0}
On-site upper aquifer	Dermal contact	1×10^2	4×10^{-2}	2×10^2	3.6×10^{-2}	4.2×10^{-2}	7.8×10^{-1}
On-site upper aquifer	Inhalation of volatiles while showering-adult only	—	6×10^{-4}	—	—	1.1×10^{-3}	
On-site lower aquifer	Ingestion	9×10^7	3×10^7	1×10^8	3.1×10^{-4}	3.6×10^{-4}	6.7×10^{-4}
On-site lower aquifer	Dermal contact	1×10^8	3×10^9	2×10^8	2.3×10^{-5}	1.2×10^{-7}	2.3×10^{-5}
Off-site upper aquifer	Ingestion	2×10^4	6×10^4	3×10^4	5.0×10^{-2}	4.7×10^{-2}	1.0×10^{-1}
Off-site upper aquifer	Dermal contact	4×10^4	1×10^4	5×10^4	1.3×10^{-3}	1.6×10^{-3}	2.9×10^{-3}
Off-site upper aquifer	Inhalation of volatiles while showering-adult only	—	6×10^{-4}	—	—	—	—
Off-site lower aquifer	Ingestion	2×10^4	5×10^3	2×10^4	1.4×10^{-1}	1.6×10^{-1}	3.0×10^{-1}
Off-site lower aquifer	Dermal contact	3×10^4	1×10^4	4×10^4	8.3×10^{-3}	9.8×10^{-3}	1.8×10^{-2}

^a Inhalation considered for adult receptor only, over 30 year exposure

6.0 ECOLOGICAL RISK ASSESSMENT

6.1 INTRODUCTION

This ecological risk assessment is part of a baseline risk assessment designed to assess the potential human health and environmental impacts associated with the Lenz Oil site located in Lemont, Illinois. According to EPA (1991) an ecological assessment consists of four main sections:

Problem Formulation: Description of ecological receptors and habitats potentially affected by site-related contamination; selection and characterization of contaminants of ecological concern; description of exposure pathways

Exposure Assessment: Quantification of contaminant release, fate and transport; measurement and estimation of exposure point concentrations; characterization of selected receptors

Ecological Effects Assessment: Toxicological effects assessment based on published toxicity benchmarks for terrestrial and aquatic receptors

Effect Characterization: Qualitative description of the potential adverse impacts to biological receptors based on information described in the previous sections.

6.1.1 Objective of the Assessment

The objective of this assessment is to determine if metals, solvents, and waste oil compounds released on the Lenz Oil site will have an adverse ecological impact on terrestrial and aquatic habitats on site, and on wetlands and aquatic habitats in the vicinity. Data collected during site-sampling efforts as well as modeling-derived data will be compared to published toxicity benchmarks to assess impacts.

6.1.2 Scope of the Investigation

The Lenz Oil site media were sampled as part of the IEPA emergency remedial activities from 1986 to 1988. The initial round of sampling provided physical and chemical data on waste materials, soils, groundwater, and ash. No ecological data were collected during this initial sampling effort. Current sampling during Phase 1 and Phase 2 of the RI has expanded the scope of media sampled to include the ephemeral ditch and background soil and sediment. However, no ecological data have been gathered as part of this RI so far.

This ecological assessment will describe potential ecological impacts to likely ecological receptors by relating site-derived chemical data, such as exposure point concentrations, to ecological receptors via exposure pathways. Because no on-site ecological survey data are available, information published in the Argonne National Laboratory (Messenger and others, 1969) biological survey, Illinois Department of Conservation (1992) information, and Forest Preserve District of DuPage County (1988) information will be used.

6.1.3 Site Characterization

Site photographs taken at the beginning of 1992 indicate that vegetation within site borders is composed of grasses, forbs, shrubs, and trees. The drainage ditch, which forms the site's northern boundary, abuts a railroad line. The ditch is approximately 5 to 7 feet wide and contains water at depths up to 2 feet. The ditch appears to have dense sedges and shrubs along the edge. Between the southeastern boundary of the site and the Des Plaines River lies a small, triangular-shaped wetland approximately 0.7 acre in size. According to the National Wetlands Inventory (DOI, 1981), this area has been classified as a seasonally flooded palustrine emergent wetland.

According to Federal Emergency Management Agency's (1988) flood insurance information, the Lenz Oil site, with the exception of the drainage ditch area, is subject to minimal flooding.

6.2 ECOLOGICAL RECEPTORS

Information on receptors that might come in contact with site-related contaminants is derived from an ecological survey conducted for the Argonne National Laboratory (Messenger and others, 1969) and a flora and fauna species list obtained from the Forest Preserve District of DuPage County (1988).

6.2.1 Potentially Affected Species

Two species listed as endangered in the state of Illinois have been reported by the Illinois Department of Conservation (1992) as occurring in the vicinity of the Lenz Oil site. One species is the river otter (*Lutra canadensis*), which has been reported on the grounds of the Argonne National Laboratory. The second endangered species is the dragonfly, Hines bog skimmer (*Somatochlora hineana*). This dragonfly has been observed in a wetland 1.5 miles away from the site.

There is no information available on receptors in the Des Plaines River along the site or on flora and fauna associated with the wetland located between the site and the river. However, in the absence of river- and wetland-specific data, it is assumed that species listed in the Forest Preserve

District document as aquatic and wetland-related could live in the Des Plaines River and the wetland between the site and the river.

According to the Argonne National Laboratory ecological survey, vegetation on the laboratory grounds includes conifer trees such as white pine (*Pinus strobus*) and Colorado blue spruce (*Picea pungens*); oak trees (*Quercus spp.*); cattails (*Typha spp.*), and other wetland-associated plants such as sedges (*Carex spp.*) and bulrush (*Scirpus sp.*); and composites such as goldenrod (*Solidago spp.*) and sunflowers (*Helianthus spp.*).

The laboratory grounds also support a diverse animal community. Mammalian species include white-tailed deer (*Odocoileus virginiana*), muskrat (*Ondatra zibethica*), raccoon (*Procyon lotor*), and various mice (*Cricetidae* Fam.); kingfisher (*Megasceryle alcyon*). Hawks (*Buteo spp.*), and mallards (*Anas spp.*) are birds found on laboratory property.

Waterfall Glen and Lemont Woods support many of the species listed in the Argonne National Laboratory ecological survey. In addition, aquatic receptors such as northern pike (*Esox lucius*), bass (*Micropterus spp.*), yellow perch (*Perca flavescens*), frogs (*Rana spp.*), and garter snakes (*Thamnophis spp.*) are mentioned. The ecological survey report and the Forest Preserve's species listing of Lemont Woods and Waterfall Glen forest preserves are provided in Appendix L of the report.

6.2.2 Potentially Affected Habitats

Based on sampling data, modeling efforts, and the history of contaminant release at the Lenz Oil site, potentially affected habitats include:

- The grounds of the site
- The ephemeral ditch at the northern periphery
- Any area between the site and the river where contaminated groundwater plumes intersect with the uppermost soil layer
- Sections of the river where contaminated groundwater plumes intersect with the sediments or riparian habitat
- The aquatic habitat portion of the river that receives effluent directly from the ditch
- The wetland bordering the site to the southeast

6.2.3 Contaminants of Ecological Concern

Contaminants of ecological concern are substances that are likely to cause adverse effects in ecological receptors. The overall approach to selecting contaminants of ecological concern usually includes the following steps:

- Evaluation of the physical and chemical properties of detected chemicals to predict their fate and transport in the environment
- Evaluation of the toxicity of detected chemicals to ecological receptors
- Analysis of frequency of detection of the chemicals in environmental media
- Comparison of detected chemical concentrations with site background data

The scope of this ecological assessment did not allow for an extensive screening process to select contaminants of ecological concern with a low degree of uncertainty. Instead, the selection of contaminants of concern focused on contaminants that exceed EPA's (1986) ambient water quality criteria (AWQC); criteria for freshwater sediments compiled by the Washington State Department of Ecology (WDOE, 1991); and contaminants that have a tendency to bioconcentrate.

As shown in Table K-1 in Appendix K, water in the ditch contains concentrations of inorganic contaminants that exceed EPA's acute and chronic ambient water quality criteria. These substances are:

- Cadmium
- Chromium (data show total chromium exceeding AWQC for hexavalent Cr five times)
- Silver
- Zinc

However, none of these contaminants is significant above background and none are considered to be CPC.

Contaminants found in the ditch sediments that exceed Wisconsin Department of Natural Resources (WDNR) (WDOE, 1991) criteria for freshwater sediments are:

- Phenanthrene
- Lead
- Selenium
- Zinc

However, none of these contaminants is significantly above background and none are considered CPC.

The bioconcentration potential of non-polar organic substances is strongly correlated to their octanol/water partitioning coefficients (K_{ow}) (Kenaga and Goring, 1980). According to K_{ow} values published in COE/EPA documentation (1991), the following substances discovered in soil and ditch sediments at the site have high bioconcentration potential:

- BAP
- Chrysene
- Benzo(a)anthracene
- Fluoranthene
- Pyrene
- Phenanthrene
- Fluorene
- Anthracene
- Bis(2-ethylhexyl)phthalate
- Naphthalene

Table K-3 shows that several contaminants detected in the groundwater exceed EPA's water quality criteria. These substances are:

- Aroclor-1242
- Aroclor-1260

Both contaminants in their original concentrations exceed acute and chronic water quality criteria, as well as human fish ingestion quality criteria. Polychlorinated biphenyls (PCB) have log K_{ow} values of 6.0 and higher. These values indicate high bioconcentration potential and environmental persistence.

Among the metals found at the site, copper, lead, and zinc have bioconcentration factors (BCF) ranging from 2.1 to 2.8. Log K_{ow} values for sediment and groundwater contaminants are shown in Table K-2 and Table K-3 in Appendix K.

6.2.4 Exposure Pathways

The objective of the exposure pathway evaluation is to select the most likely exposure pathways among the pathways by which organisms present at the site may contact site chemicals and the most important factors influencing these exposures. By identifying the most likely exposure pathways, an evaluation of potential environmental impacts can be limited to those pathways that are expected to comprise the majority of impacts to ecological receptors. Factors which influence exposures of ecological receptors to site chemicals are:

- site-specific geological, physical, and chemical conditions
- seasonal and climatic variations
- exposure point concentrations
- duration of expected exposure
- frequency of exposure

The pathways that aquatic receptors to be exposed to site chemicals are:

- exposure of benthic and epibenthic invertebrates, and demersal fish to chemicals bound to sediments
- exposure of benthic and epibenthic invertebrates, and demersal fish to chemicals found in the water column through ingestion, dermal absorption, and respiration
- exposure of benthic and epibenthic invertebrates to chemicals found in the interstitial water of the sediments through ingestion, dermal absorption, and respiration

Sampling data are available from the surface water column and from the solid portion of the sediments in the ditch. Therefore, aquatic pathways to be evaluated will include exposure to surface water and solid-phase sediments.

Exposure of terrestrial organisms to chemicals can occur through the following pathways;

- direct ingestion of chemicals from groundwater seeps and springs
- direct ingestion of chemicals in surface water
- direct ingestion of chemicals in soil
- indirect ingestion of chemicals in contaminated plants and prey
- plant root uptake of chemicals in soil
- direct dermal absorption of chemicals from surface water
- direct dermal absorption of chemicals from soil
- direct inhalation of chemicals volatilizing from groundwater

- direct inhalation of chemicals volatilizing from surface water
- direct inhalation of chemicals volatilizing from soil

Direct ingestion of chemicals from groundwater seeps and springs will not be considered in the assessment, because the presence of groundwater seeps and springs has not been confirmed.

Direct ingestion of chemicals from surface water is a likely pathway, due to the need of all terrestrial receptors for fresh water and its availability in the ditch, the river, and possibly the wetland.

Terrestrial species that feed on decaying organic material in soil or burrow through soil may directly ingest soils. This exposure pathway is the most likely for such terrestrial species, and is less likely for non-burrowing mammals and birds since soil ingestion would be incidental.

Indirect ingestion of chemicals through contaminated plants and prey is a likely pathway for both predaceous and herbivorous species. Plants are known for their potential to bioconcentrate organics (Travis and Arms, 1988). Predacious species can be subject to elevated levels of chemicals through food chain effects.

Direct dermal absorption of chemicals from groundwater is unlikely since no groundwater seeps or springs have been observed downgradient of the site.

Direct dermal absorption of chemicals from surface water is a likely pathway for species which spend some time in stagnant water, such as raccoon, river otter, and waterfowl.

Direct dermal absorption of chemicals from soil may be a pathway for those species that live in continuous contact with soils, such as burrowing mammals and subterranean insects. However, fur and feathers on these species help prevent direct dermal contact with chemicals in soil and reduce the absorption of such contact.

The exposure pathways that are based on the inhalation route are not considered significant for exposure by ecological receptors, because the contribution to total exposure from dietary exposure and contact with soil are expected to be greater than contributions from inhalation.

In summary, the highest exposure potential is associated with the following pathways:

- direct ingestion of chemicals in surface water
- direct dermal contact of chemicals in surface water
- direct uptake of chemicals through plant roots

- indirect ingestion of chemicals in contaminated food

For a complete characterization of exposure pathways please see Figure K-1 (Appendix K).

6.3 EXPOSURE ASSESSMENT

6.3.1 Quantification of Release, Fate, and Transport

Environmental media sampling data show that contaminants have been released to soil, surface water (Table K-1, Appendix K-1), sediments in the ditch (Table K-2, Appendix K), and groundwater (Table K-3, Appendix K). Sampling data from groundwater wells indicate that a plume carrying contaminants is flowing in the direction of the Des Plaines River. Monitoring well data taken from wells closest to the river indicate contamination at lower concentrations than on-site concentrations. Figure D-3 in Appendix D shows the distribution of the groundwater contamination plume. Soil samples taken near the ditch indicate contamination as well. Figure 2-3 shows the location of soils and sediment sampling stations along the ditch. Figure 2-4 shows surface water sampling stations along the ditch. None of the environmental media sampling from the ditch extended beyond the east side of State Route 83.

6.3.2 Exposure Point Concentrations

Exposure point concentrations are available for sediments and surface water in the ephemeral ditch. Soil contamination data from on-site sampling locations represent exposure point concentrations. Concentrations of contaminants measured in groundwater can be regarded as maximum exposure point concentrations for sediment areas in the wetland and the Des Plaines River which may come into contact with the groundwater plume. Exposure point concentrations associated with groundwater transport were also estimated based on the potential mixing of a contaminated groundwater plume and Des Plaines River water. Taking into account plume distribution and hydraulic conductivity, a groundwater volume flow was estimated and compared to the low-flow rate of the river. A dilution ratio of 1:400 was calculated (see Appendix D and Table K-3 in Appendix K).

6.3.3 Characterization of Receptors

Habitats associated with the Lenz Oil site host a large number of species, populations, and communities. Exposure assessments usually select a small number of receptors that serve as indicator species for the remaining biota. These receptors are supposed to be representative in terms of sensitivity, habitat requirement, and taxonomic spectrum. The indicator species are also selected

on the basis of available benchmark data that can be used as endpoints in an assessment, such as no observable adverse effect levels (NOAEL), lowest observable adverse effect level (LOAEL), lethal concentration 50% (LC50), and lethal dose 50% (LD50). Receptor characterization usually focuses on terrestrial receptors since all aquatic species are sufficiently protected by available ambient water quality criteria (EPA, 1986). Because of the lack of any data on receptor presence and their duration of stay on the Lenz Oil site or in potentially affected habitats, a complete characterization of terrestrial receptors cannot be made at this time. However, under a conservative scenario, the two previously mentioned endangered species, the river otter and bog skimmer, could be assumed to frequent the ditch and the wetland as well as the riparian zone of the Des Plaines River along a potential groundwater intersect.

Available data from the Lenz Oil site show that sediments in the ditch are heavily contaminated with organic compounds. The majority of contaminants are polycyclic aromatic hydrocarbons (PAHs) and other organic contaminants for which no sediment quality criteria or freshwater quality criteria have been developed. Aquatic receptor characterization, therefore, must take into account bioconcentration potential. Tables K-2 and Table K-3 in Appendix K show octanol/water partitioning coefficients ($\log K_{ow}$) for the contaminants. The K_{ow} values are indicators of bioconcentration potential; the higher the K_{ow} value, the higher its bioconcentration potential.

6.4 ECOLOGICAL EFFECTS ASSESSMENT

6.4.1 Aquatic Toxicity Data

Aquatic toxicity data are based on ambient water quality criteria published by EPA (1986) and on freshwater sediment criteria based on WDNR guidelines (WDOE, 1991). Table K-2 in Appendix K lists the available data for sediments. Table K-1 (Appendix K) shows the acute and chronic ambient water quality criteria for heavy metals measured above background in the surface water of the ditch. Heavy metal concentrations in the surface water of the ditch exceed acute and chronic water quality criteria by a large margin. Ingestion and respiration of surface water therefore can cause acute and chronic adverse effects to potential receptors and should be considered a serious threat to the two endangered species. Both the river otter and bog skimmer are species associated with aquatic habitat. There is also a high concentration of calcium present in the water. Although no calcium carbonate data are available, 643 mg/L calcium in the surface water can be considered to be very hard conditions. This degree of hardness can very well influence the pH of the water, as well as the toxicity of the heavy metals. EPA's water quality criteria have been based on a hardness of 100 mg/L calcium. According to EPA (1986), the toxicity of all heavy metals measured in the surface water is hardness-dependent. Increasing hardness usually correlates with decreased heavy metal toxicity, especially in the case of zinc (Rand and Petrocelli, 1984).

If groundwater contaminants are taken up by the hydrological processes of the wetland, or suffuse the sediments of the Des Plaines River, adverse effects can be expected in all organisms which come into contact with the sediments. Biota in river water in the immediate vicinity of the affected sediments can also be subject to exposure and adverse effects since chlordane, PCB-1242 and PCB-1260 concentrations also exceed EPA water quality criteria after being diluted 1/400. PCB bioconcentration has been demonstrated in algae, invertebrates, and fish (Eisler, 1987). Toxic effects of PCBs have been described as causing decreased growth in aquatic organisms, reproductive toxicity in demersal fish, carcinogenesis, and immune system suppression (Eisler, 1987).

6.4.2 Terrestrial Toxicity Data

Terrestrial toxicity data are usually based on published results of toxicity studies that have been conducted on a limited number of species in laboratories. The effects of different chemicals have been evaluated on species such as mallards, chicken, rats, white-tailed deer, dogs, rabbits, and raccoons (Patton and Dieter, 1980; Eisler, 1985 and 1987). Data from laboratory species that most closely resemble chosen indicator species are then modified for indicator species-specific uptake. For this purpose, the ingestion rates of the indicator species for water, plants, and prey, the duration and proportion of uptake of contaminated food sources, gastrointestinal absorption factors, and other parameters such as uncertainty need to be determined. However, there are currently no data available on confirmed presence of receptors, their duration of stay, and their ingestion ratios. In addition, the scope of this assessment did not allow for a thorough literature search on toxicity benchmarks and estimation of contaminant dosages in terrestrial receptors. Consequently, no assessment of ecological effects on ecological receptors via terrestrial exposure pathways was made at this point.

6.5 RISK CHARACTERIZATION

6.5.1 Adverse Effects

There are no data available indicating that biological receptors are currently experiencing adverse effects from on-site contaminants. The potential for future adverse effects depends largely on the behavior of the groundwater contaminant plume as well as on the pH and hardness of the surface water in the ditch. If water hardness in the drainage ditch is sufficiently high, the danger posed by heavy metal toxicity can be less than the data indicate.

If groundwater contaminants at their current concentrations interact with wetland and river sediments, a high likelihood exists for adverse effects to occur in receptors that come directly into

contact with sediment, feed on benthic organisms, or spend time in the water column near the affected sediments. The toxicity of PCBs is well known. PCBs and other organic contaminants for the most part have very high octanol-water partitioning coefficients and are therefore likely to adsorb to sediment particles and accumulate in fatty tissues. Log K_{ow} data in Table K-3 (Appendix K) indicate that ethylbenzene, α -chlordane, PCB-1242 and PCB-1260 have extraordinarily high bioconcentration potential. It is possible that such substances will bioaccumulate within a detritus-epibenthic prey-based food chain.

A high potential for exposure to contaminants that are bioconcentratable and exceed sediment quality criteria exists in the ditch sediment. The ditch is directly adjacent to and downslope from railroad line and appears to be densely vegetated by shrubs and sedges. Although the location of the ditch and its dense vegetation might deter some animals from foraging, a risk does exist for burrowing animals that come in contact with the ditch sediment, and for plants through root uptake of contaminants. Additional risk may arise during periods of the year when the ditch becomes dry. Not only are contaminant concentrations in the ditch apt to increase, but the sediments also become more accessible to biota which would otherwise not be exposed this way.

To address the potential for exposure of ecological receptors to site-related contamination more thoroughly, additional data need to be collected. The potential for adverse effects on terrestrial receptors exposed to uptake of contaminated soil could be described in more depth if an ecological survey of the site established the presence and duration of individual species on the site or demonstrated readily visible damage to plants or animals. Such data, in addition to a thorough literature survey, would form the basis for establishing parameters to calculate uptake dosages and allow comparisons to literature-based toxicity benchmarks.

To validate the potential for adverse effects on receptors in the wetland habitat, the presence of the wetland needs to be confirmed. Information on this wetland is dated 1981. It is therefore entirely possible that the wetland no longer exists.

Finally, to better describe the potential for adverse effects from exposure to surface water in the ditch, water quality parameters such as pH and hardness should be determined.

6.5.2 Uncertainty

Sources of uncertainty in this ecological risk assessment include the lack of baseline data of contaminants in biota, the unconfirmed presence of ecological receptors on site habitat, and the applicability of ambient water quality criteria to species other than fish and invertebrates, such as biota associated with wetland habitat, and the extrapolation of laboratory-derived toxicity data to

field situations. Because no quantitative assessment was conducted, uncertainties can only be described in a qualitative manner.

The high concentration of calcium may have a significant effect on the bioavailability and toxicity of some heavy metals. Because of the lack of hardness and pH data, uncertainty regarding the toxicity of metals to ecological receptors is high.

Uncertainty also affects the potential for adverse effects from exposure to polycyclic aromatic hydrocarbons. Aquatic toxicity data are available for only a few of these substances. PAHs for which no toxicity data are available may very well pose additional risk. Further, the potential for additive or synergistic toxic effects has not been considered, and thus constitutes a source of uncertainty.

The measurement of contaminant concentrations in the sediments did not take interstitial water concentrations into account. It is generally assumed that the major exposure to sediment-related contaminants is through the interstitial water. In addition, there is considerable uncertainty associated with the use of partitioning values for organic substances and metals. Experimental determination of partitioning coefficients reported in the literature may not accurately reflect sorption and desorption characteristics in situ.

Surface water and sediment concentrations of contaminants in the ditch were measured during the wet season. There is uncertainty as to what degree these concentrations would change once the ditch begins to fall dry.

Assumptions regarding the degree of exposure and the likelihood of adverse effects on biota exposed to α -chlordane and PCBs in sediments are subject to uncertainty. Groundwater contamination hold true only for the well locations. Depending on sorption and desorption processes along the groundwater path towards the river, contaminant concentrations of substances with high K_{ow} values may change.

Finally, the lack of sufficient information on food web relationships in the aquatic, wetland, and terrestrial habitat limits the application of data to the assessment of adverse effects.

7.0 RISK ASSESSMENT SUMMARY

The Lenz Oil baseline risk assessment has been prepared as part of the RI/FS for the site. The risk assessment is based on sample data collected from the site area in 1991 and 1992. Surface soil, subsurface soil, groundwater, surface water, sediment, and soil-gas data were collected. Contaminants detected in these media are assessed to characterize the nature and extent of the human and ecological risks posed by the site. The following sections highlight the chemicals of potential concern detected on and around the site, the significant exposure pathways associated with the site area, and the significant risks to human and ecological receptors. Sections 7.1 through 7.4 address the components of the human health risk assessment. Section 7.5 summarizes the major issues associated with the ecological assessment of the site.

7.1 CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern found at the Lenz Oil site include volatile organic compounds, semi-volatile organic compounds, pesticides, polychlorinated biphenyls (that is arochlor isomers 1242, 1254, and 1260), and metals. These contaminants are present in on-site soils, in on- and off-site groundwater, and in the sediments and surface water of an adjacent drainage ditch. No contaminants have been measured in the ambient air. Ambient air contaminant concentrations are predicted by air modeling for this risk assessment. All other exposure-point concentrations are determined from Phase 1 and Phase 2 sample data.

Contaminants from all the above-mentioned categories have been measured in on-site soils. The contaminants pyrene, xylene, and several metals have been detected in drainage ditch surface waters at concentrations that do not pose significant human health risks. Acetone, PAHs, and several metals have been detected in drainage ditch sediments. These contaminants also are not present at concentrations that result in significant human health risks.

Surface soil samples were collected from the north and south banks of the drainage ditch in order to assess contaminant flow patterns into the ditch. Similar PAH compounds were detected on both sides of the ditch at concentrations within the same order of magnitude. Detection of these compounds on the Lenz Oil side of the ditch indicates that contaminants detected in soils on the site may be migrating into the drainage ditch. Contaminants found on the far side of the ditch may also be a result of past operations on the site, or may be migrating from an alternative source (for example, the railroad tracks).

Volatile organic compounds were detected only on the Lenz Oil side of the ditch only. These compounds range in concentration from approximately 10 to 70 parts per billion, and include

acetone, trichloroethene, tetrachloroethylene, chloroethene, ethylbenzene, and xylene. The presence of these compounds indicates that contaminants present in soils on the site are migrating into the ditch.

Specific compounds of concern detected in on-site soils and in groundwater that pose significant health risks are discussed in Section 7.4.

7.2 EXPOSURE ASSESSMENT

The exposure assessment identifies receptors that are potentially exposed to on- or off-site contaminants. Receptors include current residents, trespassers, recreational users, and potential future residents and short-term workers on the site or in the site area.

No surface water users were identified on the Des Plaines River. Significant contaminant impacts on the river are not predicted. An assessment of groundwater contaminant flow into the river indicates that contaminants potentially released to the river would be present at concentrations below ambient water quality criteria. In addition, monitoring data obtained to date not indicate that the groundwater contaminant plume has affected the river.

Potential exposure of recreational receptors to site-related contaminants (for example, swimmers and boaters) in the Des Plaines River and in the drainage ditch are assessed. Ingestion and dermal contact with surface water, and dermal contact with sediments are also considered. Contaminants are not present at concentrations that result in significant human health impacts.

Exposure to occasional site trespassers and current and future residents are considered in the exposure assessment. The trespasser and current residential receptors are introduced separately in the exposure assessment, and are then combined in the discussion in Section 5.4.3 of the risk assessment. Assumptions are made that persons living adjacent to the site may inhale organic compound emissions released from contaminated soils on the site, and may come in direct contact with contaminated soils on the site while trespassing.

Future residential receptors are identified in the exposure assessment. Both on- and off-site future residents are then considered in Section 5.4.4 and 5.4.5 of the risk assessment. On-site resident may come in contact with contaminated soil on the site and may drink contaminated groundwater obtained from the aquifer beneath the site. Off-site residents may trespass on the site, and may drink contaminated groundwater from the off-site aquifer. A future on-site short-term construction worker scenario is also considered.

Potential chemical exposures and risk to trespassers, residents, and workers are summarized in Section 7.4 and in Section 5.0.

7.3 TOXICITY ASSESSMENT

Available toxicity factors for carcinogens and noncarcinogens are listed in Section 4.0 for the contaminants of concern at the site. Contaminants at the site that potentially can cause the most significant health risks are also discussed in Section 4.0. Toxicity profiles for site contaminants that are driving the risks at the site are presented in Appendix H.

Contaminants that result in significant risks at the site include the arochlor isomers, carcinogenic PAHs, pesticides (that is, chlordane, Gamma-BHC, DDE, DDD), trichloroethene, and chloroform. Chromium may also present a significant risk in the groundwater pathway. This is based on the conservative assumption that chromium is present in the hexavalent form.

7.4 RISK CHARACTERIZATION

The most significant cancer risks for a future residential receptor using contaminated on-site groundwater range from 4×10^{-2} to 4×10^{-8} . A hazard index of 1.7 is also predicted for this pathway. Contaminants of primary concern are PCBs, chloroform trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, benzene, and vinyl chloride. The most significant cancer risks for a future residential receptor using contaminated off-site groundwater range from 10^{-4} to 10^{-5} , and the hazard indices range from 1.7 to 6.9×10^{-3} .

The most significant soil ingestion and dermal contact cancer risks for a future on-site receptor are 10^{-5} . Contaminants of primary concern are PCBs, arochlor isomers, and carcinogenic polycyclic aromatic hydrocarbons (PAHs). The PAHs include BAP and equivalent compounds. Soil cancer risks resulting from ingestion and dermal contact exposures of shorter durations (that is, for trespassers and short-term workers) are in the 10^{-8} range.

The most significant inhalation cancer risks for current and future residential receptors on or adjacent to the site range from 10^{-2} to 10^{-3} . Contaminants of primary concern are carcinogenic PAHs, trichloroethylene, tetrachloroethene, and the pesticides aldrin, chlordane and Gamma-BHC. The hazard index predicted from exposure to this pathway is less than 0.1. Inhalation cancer risks resulting from shorter exposure durations (for example, future on-site workers) are in the 10^{-4} range. Predictions of risks due to inhalation are based on conservative air modeling, and the use of soil boring data from 0 to 2.5, to 0 to 5 feet deep to characterize chemical concentrations in surface soil. Therefore, these risks are likely to be less significant.

For comparison, excess cancer risks and hazard indices based on less conservative (central tendency) exposure assumptions were also calculated. All central tendency risks were within slightly more than one order of magnitude (up to 20 times) less than RME risks calculated for the same pathways.

7.5 ECOLOGICAL CHARACTERIZATION

Currently, there are no data available that indicate that biological receptors are experiencing adverse effects from on-site contaminants. The potential for future adverse effects depends largely on the behavior of the groundwater contaminant plume as well as on the pH and hardness of the surface water in the ditch. Potential adverse effects can be expected in detritus-epibenthic prey-based food chains in the ditch, wetland, and river habitat. Burrowing mammals also face adverse effects if they come in contact with groundwater or ditch sediments. The greatest threat to ecological receptors is posed by heavy metals, and polycyclic aromatic hydrocarbons.

8.0 REFERENCES

- Centers for Disease Control (CDC), 1985. Preventing Lead Poisoning in Young Children: Statement by CDC, 99-2230.
- Clement Associates, Inc. (Clement), 1988. Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons. Interim Final Report.
- Department of the Interior (DOI), 1981. National Wetlands Inventory. Sag Bridge, Illinois. November 1981.
- Ebasco Services, Inc. (Ebasco), 1992. Technical Memorandum 3B, Remedial Investigation, Lenz Oil Services, Inc., Lemont, Illinois. Ebasco Services Incorporated. January 15, 1992.
- Ecology, 1991. Summary of Criteria and Guidelines for Contaminated Freshwater Sediments. September 1991. Department of Ecology, Washington State.
- Eisler, R., 1985. Cadmium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biol. Rep. 85 (1.2).
- Eisler, R., 1987. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biol. Rep. 85 (1.11).
- Environmental Resources Management - North Central, Inc. (ERM), 1990. Remedial Investigation/Feasibility Study Sampling and Analysis Plan, Lenz Oil Service, Inc. Lemont, Illinois, Revision 2. Environmental Resources Management-North Central, Inc., October 19, 1990.
- ERM, 1991a. Technical Memorandum No. 1, Description of Current Situation Report, Remedial Investigation, Phase I, Task I, Lenz Oil Service, Inc., Lemont, Illinois. Environmental Resources Management-North Central, Inc. February 5, 1991.
- ERM 1991b. Technical Memorandum No. 2, Soil Gas Investigation, Remedial Investigation, Phase I, Task I, Lenz Oil Service, Inc., Lemont, Illinois. Environmental Resources Management-North Central, Inc. February 5, 1991.
- ERM, 1991c. Phase II Work Plan - Part A, Remedial Investigation/Feasibility Study, Lenz Oil Services, Inc., Revision 2. Lemont, Illinois. Environmental Resources Management-North Central, Inc. December 30, 1991.
- ERM, 1992a. Technical Memorandum No. 3A, Remedial Investigation, Phase I, Task 2, Lenz Oil Services, Inc., Lemont, Illinois, Volume 3 of 3. Environmental Resources Management, North Central, Inc. January 15, 1992.
- ERM, 1992b. Correspondence From David Edwards of Environmental Resources Management, North Central, Inc. to Nan Gowda of U.S. Environmental Protection Agency, Region V. March 6, 1992.
- ERM 1992c. Phase II Sample Results, Remedial Investigation/Feasibility Study, Lenz Oil Services, Inc., Lemont, Illinois. Environmental Resource Management-North Central, Inc. May 4, 1992.

- Federal Emergency Management Agency (FEMA), 1988. Flood Insurance Map. FIA-14 / May 1988.
- Forest Preserve District of DuPage County, 1988. Plant and Animal Species Lists from Lemont Woods and Waterfall Glen Forest Preserves.
- Halls, L., 1984. White Tailed Deer. Report from the Wildlife Management Institute.
- Illinois Department of Conservation (IDC), 1992. Letter from Glen Kruse, Illinois Department of Conservation to Kris Kruk, PRC regarding information on endangered species from the Illinois Natural Heritage Database. March 3.
- Kenaga, E.E. and C.A.I. Goring, 1980. Relationship between Water Solubility, Soil Sorption, Octanol-Water Partitioning, and Concentration of Chemicals in Biota. In: J.G. Eaton, P.R. Parrish, and A.C. Hendricks (Eds.), Aquatic Toxicology, ASTM STP 707.
- Messenger, A.S. and others, 1969. Ecological Survey of Argonne National Laboratory. Argonne National Laboratory. ANL-7559.
- National Institute for Environmental Health Sciences, 1989. Fifth Annual Report on Carcinogens. NTP-89-239.
- National Library of Medicine (NLM), 1990. Hazardous Substances Data Bank.
- NOAA 1990. 1990 Local Climatological Data - Annual Summary with Comparative Data - Chicago International Airport, Illinois. National Oceanic and Atmospheric Administration, U.S. Department of Commerce, National Climatic Data Center, Asheville, N.C.
- Patton, J.F. and M.P. Dieter, 1980. Effects of Petroleum Hydrocarbons on Hepatic Function in the Duck. Comp. Biochem. Physiol. 65C.
- PRC 1992a. Record of Telephone Conversation between Ms. Kris Kruk of PRC and Mrs. William Gruber. PRC, Environmental Resources Management, Inc. May 14, 1992.
- PRC 1992b. Phase II Data Validation Review, Letter Report to EPA. PRC Environmental Resources Management, Inc. July 2, 1992.
- Rand, G.M and S.R. Petrocelli, 1984. Fundamentals of Aquatic Toxicology. Hemisphere Publishing Corporation. ISBN 0-89116-302-6.
- Ryan, Elizabeth A., 1987. Assessing Risks from Dermal Exposure at Hazardous Waste Sites. Proceedings of The 8th National Hazardous Material Control Research Institute Superfund 1987 Conference. Washington, D.C. November 16-18, 1987
- Travis, C.C. and A.D. Arms, 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environ. Sci. Technol. Vol.22. No.3.
- U.S. Army Core of Engineers (COE)/U.S. Environmental Protection Agency (EPA), 1991. Evaluation of Dredged Material Proposed for Ocean Disposal. EPA-503/8-91/001. February 1991.
- U.S. Environmental Protection Agency (EPA), 1986a. Federal Register. Guidelines for the Health Risk Assessment of Chemical Mixtures. Volume 51, No. 185, pp. 34014 to 34025.
- EPA, 1986b. Quality Criteria for Water. Office of Water Regulations and Standards, EPA 440/5-86-001.

- EPA, 1988a. Data Functional Guidelines for Evaluation of Organic Analyses. U.S. Environmental Protection Agency. February 1988.
- EPA, 1988b. Laboratory Data Functional Guidelines for Evaluation of Inorganic Analyses. U.S. Environmental Protection Agency. July 1988.
- EPA, 1988c. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final. Office of Solid Waste and Emergency Response Directive 9355.3-01, EPA/540/6-89/004. U.S. Environmental Protection Agency. October 1988.
- EPA, 1989a. Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final, EPA/540/1-89/001. U.S. Environmental Protection Agency. March 1989.
- EPA, 1989b. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, U.S. Environmental Protection Agency. December 1989.
- EPA, 1990a. Exposure Factors Handbook. Office of Health and Environmental Assessment, EPA 600/8-89/043. U.S. Environmental Protection Agency. March 1990.
- EPA, 1990b. Federal Register. National Oil and Hazardous Substances Pollution Contingency Plan. Volume 55, No. 46.
- EPA, 1991a. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Offices of Solid Waste and Emergency Response Directive 9285.6-03. U.S. Environmental Protection Agency. March 25, 1991.
- EPA, 1991b. National Functional Guidelines for Organic Data Review. U.S. Environmental Protection Agency.
- EPA, 1991c. Ecological Assessment of Superfund Sites: An Overview. Office of Solid Waste and Emergency Response, ECO Update Intermittent Bulletin Volume 1, Number 2, Publication 9345.0-05I. December 1991.
- EPA, 1992a. Dermal Exposure Assessment: Principles and Applications. Office of Health and Environmental Protection Agency, EPA/600/8-91/011B. March 25, 1991.
- EPA, 1992b. Integrated Risk Information System (IRIS). On-Line Database.
- EPA, 1992c. Health Effects Assessment Summary Tables, Annual Update, FY 1992. OHEA ECAO-CIN-821.
- EPA, 1991d. Supplemental Guidance for Superfund Risk Assessments in Region 10. U.S. EPA Region 10. August 23, 1991.

APPENDIX A
BASELINE RISK ASSESSMENT REPORT

APPENDIX A
HISTORICAL DATA SUMMARIES

TABLE 4-1

REPORTED CONTAMINANTS IN LENZ OIL DRUMS,
TANKS, AND TANK TRUCKS

<u>Contaminant</u>	<u>Range of Concentrations Detected</u>			
Antimony	<0.5	-	26.2	mg/kg
Aroclor 1016	<5.0	-	25.0	mg/kg
Aroclor 1242	<5.0	-	85.0	mg/kg
Aroclor 1248	<5.0	-	62.0	mg/kg
Aroclor 1260	<5.0	-	26.0	mg/kg
Arsenic	0.35	-	33.94	mg/kg
Barium	<200	-	1020.0	mg/kg
Beryllium	<2.0	-	2.5	mg/kg
Cadmium	<20	-	30.0	mg/kg
Chromium	<20	-	1235.0	mg/kg
Copper	<10	-	345.0	mg/kg
Cyanide, Reactive	<5	-	349.0	mg/kg
Cyanide, Total	<5	-	165.0	mg/kg
Lead	<4.6	-	2030.0	mg/kg
Mercury	<1.0	-	4.06	mg/kg
Nickel	<1.9	-	350.0	mg/kg
PCBs, Total	<5	-	85.0	mg/g
Selenium	<0.6	-	0.14	ug/l
Zinc	<20.0	-	6310.0	mg/kg
Naphthalene	N/A	-	9100.0	ug/g
Methyl Naphthalene	N/A	-	4700.0	ug/g
Dimethyl Naphthalene	N/A	-	3000.0	ug/g
Trimethyl Naphthalene	N/A	-	1920.0	ug/g
Anthracene	N/A	-	510.0	ug/g
1,1-dichloroethane	N/A	-	93.0	ug/g
1,1,1-Trichloroethane	N/A	-	11,000.0	ug/g
Trichloroethylene	N/A	-	5,100.0	ug/g
Benzene	N/A	-	16,000.0	ug/g
Tetrachloroethylene	N/A	-	7,900.0	ug/g
Toluene	N/A	-	45,000.0	ug/g
Ethyl Benzene	N/A	-	33,000.0	ug/g
Xylene	N/A	-	77,100.0	ug/g
Phenol	N/A	-	54,000.0	ug/l
2,4-dimethylphenol	N/A	-	4,800.0	ug/l

NOTE: N/A - Not Available

TABLE 4-2

**REPORTED CONTAMINANTS IN SURFACE IMPOUNDMENTS
(ALL RESULTS IN mg/Kg)**

<u>Parameter</u>	<u>Flow from Surface Impoundment</u>	<u>Surface Impoundment</u>
Organics and PCBs		
Phenol Ethanone	51	23
Aliphatic Acids	92	< 0.5
Aliphatic Acid Esters	55	< 0.5
Cyclohexanone	57	< 0.5
Other Organic Compounds	400	150
Phenol	27	54
2,4-Dimethylphenol	< 0.5	4.8
Methyl Phenol	Trace	7.9
Phenoxy Ethanol	150	93
Methyl Benzene Methanol	600	340
Benzene Ethanol	130	69
Methyl Benzene Ethanol	230	120
Butoxy Ethanol	130	57
Butoxy Ethoxy Ethanol	190	38
Ethoxy Butoxy Ethoxy Ethanol	79	63
Other Aliphatic Alcohols	220	640
PCBs	< 0.05	0.0003
Metals		
Chromium	0.06	ND
Copper	ND	0.05
Iron	8.4	5.3
Lead	ND	0.28
Manganese	5.44	ND
Mercury	0.00406	0.00218
Zinc	ND	2.8

Note: ND = Not Detected

TABLE 4-3
REPORTED CONTAMINANTS IN ON SITE SOILS
(Page 1 of 3)

Parameter	Concentration Range
<u>Metals</u>	<u>(mg/kg)</u>
Aluminum	NA - 37960
Antimony	<0.006
Arsenic	<2.09 - 14.3
Barium	<200 - 3250
Beryllium	<0.091 - 2.64
Cadmium	<0.054 - 8.57
Chromium	<0.008 - 43.6
Cobalt	<10 - 11.3
Copper	<5 - 62.1
Iron	N/A - 33800
Lead	N/A - 1250
Maganese	N/A - 835
Mercury	<0.01 - 0.14
Nickel	<0.36 - 35.8
Selenium	<0.25 - 0.66
Silver	<0.18 - 7.97
Thallium	<0.17 - 3.9
Varadium	<10 - 81.2
Zinc	N/A - 440
<u>Volatile Organics</u>	<u>(ug/kg)</u>
1,1-Dichloroethane	<5 - 68000
Trans - 1,2Dichlroethene	<5 - 80000
2-Butanone	<10 - 2800
1,1,1-Trichloroethane	<5 - 85000

TABLE 4-3
REPORTED CONTAMINANTS IN ON SITE SOILS
(Page 2 of 3)

Trichloroethene	<5 - 140000
Benzene	<5 - 8500
4-Methyl-2-pentanone	<10 - 15000
Tetrachloroethene	<5 - 32000
Toluene	<5 - 890000
Ethylbenzene	<5 - 26000
Total Xylenes	<5 - 2000000

Semi-Volatile Organics

(ug/kg)

1,2-Dichlorobenzene	<330 - 34000
4-Methylphenol	<330 - 11000
Isophorone	<330 - 9200
2,4-Dimethylphenol	<330 - 5000
Naphthalene	<330 - 30000
2-Methylnaphthalene	<330 - 65000
Acenaphthlene	<330 - 2400
Phenol	<330 - 10000
Dibenzofuran	<330 - 1700
Fluorene	<330 - 3500
Phenanthrene	<330 - 12000
Anthracene	<330 - 2100
Di-n-butylphthalate	<330 - 3500
Fluoranthene	<330 - 7500
Pyrene	<330 - 5500
Butylbenzylphthalate	<330 - 2400
Benzo(a)anthracene	<330 - 3300
Chrysene	<330 - 3400
bis(2-Ethylhexyl)phthalate	<330 - 27000

TABLE 4-3
REPORTED CONTAMINANTS IN ON SITE SOILS
(Page 3 of 3)

Benzo(b)fluoranthene	<330 - 2500
Benzo(a)pyrene	<330 - 2300
Indeno(1,2,3-cd)pyrene	<330 - 1300
Benzo(g,h,i)perylene	<330 - 1800

TABLE 4-4
REPORTED CONTAMINANTS IN
INCINERATOR ASH

<u>Analyte</u>	<u>Concentration Range (ug/lq)</u>
Isophorone	<115 - 1800
Naphthalene	< 115
2-Methylnaphthalene	<1,000
Phenanthrene	<1,000
Pyrene	< 115
bis (2-ethylhexyl) phethalate	<1,000
Fluoranthene	< 115

Note: No volatile organic analysis available.

TABLE 4-5
REPORTED CONTAMINATION IN TENT SAMPLES

Parameter	Detection Limits (ug/kg)	Max. Detected Concentration (ug/kg)
Isophorone	20000	12000J
Naphthalene	20000	35000
2-Methylnaphthalene	20000	- 36000
Acenaphthlene	20000	4400J
Dibenzofuran	20000	4200J
Fluorene	20000	5600J
Phenanthrene	20000	17000J
Anthralene	20000	3100J
Di-n-butylphthalane	20000	1800J
Fluoranthene	20000	7900J
Pyrene	20000	9200J
Butylbenzlpthalate	5000	490J
Benzo(a)anthracene	20000	3400J
Chrysesne	20000	3400J
bis(2-Ethylhexyl)phthalate	20000	17000JB

Notes:

(1) J - Indicates that the compound was analyzed for and detected at concentrations below the detection limit. The reported value is estimated.

B - The analyte was also found in the blank.

TABLE 4-7

**REPORTED CONTAMINANTS IN PRIVATE WELLS
(ALL RESULTS IN mg/l)**

	<u>RESIDENCE/SAMPLING DATE</u>						
	<u>WILLIAMS</u> <u>(11/6/86)</u>	<u>BOWLES</u> <u>(11/6/86)</u>	<u>GRUBER</u> <u>(11/6/86)</u>	<u>MASON</u> <u>(11/6/86)</u>	<u>WILLIAMS</u> <u>(3/5/85)</u>	<u>WILLIAMS</u> <u>(6/3/87)</u>	<u>WILLIAMS</u> <u>(7/29/86)</u>
<u>Metals</u>							
Barium	0.080	<0.050	<0.050	<0.050	<0.1	0.063	N/A
Chromium	0.015	<0.010	0.013	<0.010	N/A	N/A	N/A
Copper	0.173	2.99	0.052	0.021	N/A	N/A	N/A
Iron	2.03	0.257	0.563	2.13	1.80	1.55	N/A
Lead	0.008	0.021	0.008	0.005	<0.05	1.55	N/A
Manganese	0.048	0.022	0.038	0.072	<0.04	0.007	N/A
Silver	0.070	0.188	0.040	0.011	<0.010	0.016	N/A
Vanadium	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	N/A
Zinc	0.110	0.585	0.239	0.053	<0.010	0.056	N/A
<u>Volatile Organics</u>							
Acetone	<0.005	<0.005	0.012	<0.005	0.710	<0.005	<0.005
Chloroethane	<0.005	<0.005	<0.005	<0.005	Trace	0.011	0.010
Benzene	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005
Ethylbenzene	<0.005	<0.005	<0.005	<0.005	Trace	<0.005	<0.005
Xylene	<0.005	<0.005	<0.005	<0.005	Trace	<0.005	<0.005

Note: N/A = Not Applicable

TABLE 4-8

REPORTED CONTAMINANTS IN LENZ OIL GROUND WATER

<u>Contaminant</u>	<u>Range of Concentrations Detected</u>		
Chloroethane	<10	-	112.0 ug/l
C-1,2dichloroethene	<5	-	460.0 ug/l
1,2-dichloroethane	<5	-	215.0 ug/l
1,1,1-trichloroethane	<5	-	252.0 ug/l
Benzene	<5	-	110.0 ug/l
Vinyl Chloride	<10	-	22.0 ug/l
Tetrachloroethene	<5	-	7.4 ug/l
1,1-dichloroethane	<5	-	200.0 ug/l
Toluene	<5	-	1,000.0 ug/l
2-butanone(methyl ethyl ketone)	<10	-	13,700.0 ug/l
Ethylbenzene	<5	-	43.0 ug/l
Xylene, Total	<5	-	180.0 ug/l
PCBs, Total	N/A		200.0 ug/l
Naphthalene	<10	-	13.0 ug/l
Methyl Naphthalene	<10	-	47.0 ug/l
Dimethyl Naphthalene	N/A		100.0 ug/l
Trimethyl Naphthalene	N/A		80.0 ug/l
Anthracene	<10	-	45.0 ug/l
1,2-dichloroethylene	<5	-	61.0 ug/l
Isophorone	<10	-	32.0 ug/l
Phenol	<10	-	Trace ug/l

NOTE: N/A - Not Applicable

APPENDIX B
STATISTICAL METHOD FOR COMPARISON WITH BACKGROUND LEVEL

APPENDIX B

STATISTICAL METHOD FOR COMPARISON WITH BACKGROUND LEVEL

PRC identified background locations for four media (ground water, surface water, sediment, and soil). For ground water, PRC selected two sampling locations to represent background. Monitoring Well G101, just north of the site, was used to represent background for the upper aquifer only. It was not used to represent background for the lower aquifer because samples have shown that the lower aquifer may be affected by site-related contaminants at this well location. Therefore, Monitoring Well MW-7D, located along the southwest edge of the site near Illinois Route 83, was used to represent background for the lower aquifer. Sampling has shown this well to be outside of the identified contaminant plume at the site. For drainage ditch surface water, PRC used data from one sample location taken just upgradient from the site. For drainage ditch sediment, PRC used a single sample taken at the same location just upgradient from the site. For surface soils and subsurface soils, PRC used data from three soil borings taken in the open field north of the site.

Two cases were considered. In the first case, only a single sample was available to characterize background concentrations. Concentrations detected in the single sample were assumed to represent mean background concentrations. In this situation, a "one-tailed hypothesis concerning the mean" was used (see Zar, 1974). For the second case, mean standard deviation and population size for concentration of the compound were available for the background environment. A "one-tailed test to differentiate between two means" was considered for this case.

A mean standard deviation and population size were available for site data for each medium being considered. The task was to identify, within a specified probability (95%), those compounds found in the environment as a result of contamination at the site. The equations used for each case are described:

- a) For the one-tailed hypothesis concerning the mean, the hypotheses proposed were:

$$H_0 : \mu \leq c \quad \text{and} \quad H_a : \mu > c \quad (B-1)$$

where: c = known mean for uncontaminated conditions
 μ = population mean at contaminated site

The standard error of the mean was computed as:

$$s_{\bar{x}} = \frac{s}{\sqrt{n}} \quad (B-2)$$

where: s = population standard deviation at contaminated site

n = population size at contaminated site

Because the population sizes for the site are small, the t-student probability distribution was used. The number of degrees of freedom are equal to the population size minus one (n-1). The t value was calculated as follows:

$$t = \frac{\bar{x} - c}{s_{\bar{x}}} \quad (B-3)$$

where: \bar{x} = sample mean

From the one-sided tables for the t-student distribution for (n-1) degrees of freedom, the value of t critical was obtained.

b) For the one-tailed test for difference between two means, the hypothesis was;

$$H_o : \mu_1 \leq \mu_2 \quad (B-4)$$

The t critical value was obtained from the one-tailed t-distribution for (n1+n2-2) degrees of freedom. The following values were computed for each test:

$$Sp^2 = \frac{(n_1 - 1) S_1^2 + (n_2 - 1) S_2^2}{n_1 + n_2 - 2} \quad (B-5)$$

$$S\bar{x}^1 - \bar{x}_2 = \sqrt{\frac{Sp^2}{n_1} + \frac{Sp^2}{n_2}} \quad (B-6)$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S\bar{x}^1 - \bar{x}_2} \quad (B-7)$$

where:

\bar{x}_1 = mean of the population at the contaminated site

s_1 = standard deviation of the population

n_1 = population size
 \bar{x}_2 = mean concentration for uncontaminated conditions
 s_2 = standard deviation for uncontaminated conditions
 n_2 = population size for uncontaminated conditions

For each of the cases, the t value was compared against the t critical. The following conclusions were reached:

- If t value is greater than t critical, reject H_0 and accept H_a . For this case, the compound was determined to be a result of the contamination at the site.
- If t value is less than or equal to t critical, accept H_0 . For this case, the compound was determined to be due not to contamination induced at the site, but rather to a natural occurrence.

PRC did not consider volatile organic compounds (VOC) identified in background samples to represent natural background. Therefore, no VOCs were eliminated based on a comparison to background.

REFERENCES

Zar, J.H., 1974. Biostatistical Analyses. Prentice-Hall, Englewood Cliffs, NS.

APPENDIX C
STATISTICAL SUMMARIES

LENZ OIL SITE
GROUND-WATER ORGANICS
AREA A - UPPER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CHLOROETHANE	1/8	95-95	21.8	95	33.3	49.7
ACETONE	1/8	17-17	6.50	17	4.24	10.0
1,1-DICHLOROETHENE	1/8	4.5-4.5	6.50	4.5	7.56	12.8
1,1-DICHLOROETHANE	4/9	2.2-28	7.32	28	8.39	13.7
1,2-DICHLOROETHENE	1/7	3.0-3.0	6.85	3.0	8.08	14.3
CHLOROFORM	1/7	14-14	5.21	14	4.07	8.97
TRICHLOROETHENE	1/7	2.2-2.2	6.75	2.2	8.15	14.2
BENZENE, HEXADECONE	1/8	313-313	45.1	313	109	136
TOLUENE	1/8	140-140	23.5	140	47.6	63.3
ETHYLBENZENE	3/9	133-390	90.5	390	145	202
XYLENES (TOTAL)	3/9	297-1667	295	1667	562	728
NAPHTHALENE	2/5	460-800	254	800	364	706
2-METHYLNAPHTHALENE	2/5	1800-4000	1162	4000	1767	3356
ACENAPHTHENE	1/5	72-72	17.4	72	30.5	55.3
DIBENZOFURAN	1/5	76-76	18.2	76	32.3	58.4
FLUORENE	2/5	120-420	110	420	181	334
PHENANTHRENE	3/5	1.0-1000	269	1000	434	808
DI-N-BUTYLPHTHALATE	1/5	1.0-1.0	4.20	1.0	1.78	6.42
AROCHLOR-1242	1/5	160-160	32.4	160	71.3	121
AROCHLOR-1260	2/5	51-97	29.9	97	43.4	83.8

LENZ OIL SITE
GROUND-WATER INORGANICS
AREA A - UPPER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
BERYLLIUM	1/5	2.2-2.2	1.17	2.2	0.648	1.97

LENZ OIL SITE
GROUND-WATER ORGANICS
AREA B - UPPER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
VINYL CHLORIDE	2/5	11-13	7.80	13	3.89	12.6
CHLOROETHANE	2/5	4.0-5.0	4.80	5.0	0.447	5.35
1,1-DICHLOROETHENE	3/5	3.0-5.0	4.10	5.0	1.24	5.64
1,1-DICHLOROETHANE	3/5	58-70	39.1	70	32.6	79.5
1,2-DICHLOROETHENE	3/5	15-21	12.5	21	8.32	22.8
1,1,1-TRICHLOROETHANE	3/5	83-120	64.1	120	56.7	135
TETRACHLOROETHENE	1/5	3.0-3.0	3.60	3.0	1.29	5.20
TRICHLOROETHENE	2/5	3.0-6.0	4.30	6.0	1.48	6.14
DI-N-BUTYLPHTHALATE	1/2	3.0-3.0	4.00	3.0	1.41	16.7

LENZ OIL SITE
GROUND-WATER INORGANICS
AREA B - UPPER UNIT (UG/L)

Parameter

Adjusted
Detection
Frequency

Range
Low/high

Arithmetic
Mean

Maximum
Mean

Standard
Deviation

Confidence
Interval

LENZ OIL SITE
GROUND-WATER ORGANICS
AREA A - LOWER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CHLOROETHANE	2/10	24-53	11.7	53	15.6	22.9
BENZENE, HEXADECONE	1/10	10-10	4.25	10	2.37	5.94
TOLUENE	1/10	4.0-4.0	3.65	4.0	1.24	4.54
DIETHYLPHTHALATE	1/5	1.0-1.0	4.20	1.0	1.78	6.42
DI-N-BUTYLPHTHALATE	1/5	1.0-1.0	4.20	1.0	1.78	6.42

LENZ OIL SITE
GROUND-WATER INORGANICS
AREA A - LOWER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval

LENZ OIL SITE
GROUND-WATER ORGANICS
AREA B - LOWER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
VINYL CHLORIDE	1/3	15-15	8.33	15	5.77	22.6
1,1-DICHLOROETHENE	1/3	3.0-3.0	3.50	3.0	1.32	6.78
1,1-DICHLOROETHANE	1/3	58-58	21.8	58	31.3	99.7
1,2-DICHLOROETHENE	1/3	10-10	5.83	10	3.81	15.3
1,1,1-TRICHLOROETHANE	1/3	62-62	23.1	62	33.6	107
DI-N-BUTYLPHTHALATE	1/2	1.0-1.0	3.00	1.0	2.82	28.4

LENZ OIL SITE
GROUND-WATER INORGANICS
AREA B - LOWER UNIT (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CALCIUM	2/2	127000-18600	156500	186000	41719	531327
CHROMIUM (TOTAL)	2/2	6.6-42	24.4	42	25.1	251
ZINC	1/2	22-22	14.7	22	10.0	105

LENZ OIL SITE
SURFACE SOIL ORGANICS
AREA A (UG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
METHYLENE CHLORIDE	1/7	100-100	22.2	100	34.4	54.1
1,1-DICHLOROETHANE	2/7	4.0-5.0	4.78	5.0	1.65	6.31
1,1,1-TRICHLOROETHANE	5/7	3.0-25	7.64	25	7.62	14.6
TRICHLOROETHENE	3/7	5.5-11	5.78	11	2.78	8.35
TETRACHLOROETHENE	6/7	2.0-15	7.50	15	4.05	11.2
TOLUENE	6/7	4.0-38	18.1	38	13.0	30.1
ETHYLBENZENE	3/6	11-29	11.7	29	9.57	21.8
XYLENES (TOTAL)	3/6	67-150	51.8	150	58.6	113
1,2-DICHLOROBENZENE	1/5	140-140	193	140	29.9	230
NAPHTHALENE	2/7	48-60	164	60	75.3	234
2-METHYLNAPHTHALENE	5/7	72-1200	312	1200	395	677
ACENAPHTHENE	3/7	64-270	181	270	69.8	246
DIBENZOFURAN	1/7	170-170	200	170	15.5	214
FLUORENE	3/7	100-370	205	370	84.2	283
PHENANTHRENE	5/7	235-2400	612	2400	799	1351
ANTHRACENE	4/7	45-560	208	560	167	362
DI-N-BUTYLPHTHALATE	1/5	43-43	174	43	73.1	264
FLUORANTHENE	6/7	89-2500	636	2500	846	1418
PYRENE	6/7	89-2300	555	2300	784	1280
BENZO(a)ANTHRACENE	3/7	144-1000	312	1000	304	593
BIS(2-ETHYLHEXYL)PHTHALATE	2/7	200-280	239	280	49.6	285
CHRYSENE	5/7	91-1100	298	1100	360	631
BENZO(b)FLUORANTHENE	3/7	200-1100	344	1100	334	654
BENZO(k)FLUORANTHENE	2/7	160-610	259	610	156	403
BENZO(a)PYRENE	1/7	810-810	291	810	229	503
INDENO(1,2,3,c,d)PYRENE ..	1/7	560-560	256	560	134	380
BENZO(g,h,i)PERLYENE	1/7	520-520	251	520	119	361
AROCHLOR-1242	5/5	110-415	248	415	140	422
AROCHLOR-1260	5/5	31-130	64.1	130	39.8	114

LENZ OIL SITE
SURFACE SOIL INORGANICS
AREA A (MG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
ANTIMONY	4/5	0.000-7.0	2.18	7.0	3.18	6.12
BERYLLIUM	5/5	0.53-1.1	0.834	1.1	0.231	1.12
CADMIUM	5/10	0.71-1.5	0.950	1.5	0.405	1.24
CALCIUM	12/12	18700-133000	82996	133000	35611	105622
CHROMIUM (TOTAL)	12/12	20-65	42.6	65	14.3	51.8
LEAD	12/12	102-663	369	663	205	499
ZINC	12/12	132-425	265	425	101	329

LENZ OIL SITE
SOIL BORING ORGANICS
AREA A (UG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
METHYLENE CHLORIDE	2/19	100-220	25.3	220	51.6	50.2
ACETONE	6/19	64-1600	176	1600	402	370
CARBON DISULFIDE	2/19	36-110	12.5	110	24.8	24.5
1,1-DICHLOROETHANE	4/19	2.0-150	13.1	150	33.3	29.1
2-BUTANONE	2/9	240-360	71.5	360	133	174
1,1,1-TRICHLOROETHANE	11/19	3.0-25	7.42	25	5.94	10.2
TRANS-1,3-DICHLOROPROPENE	3/18	6.0-14	7.08	14	4.57	9.35
TRICHLOROETHENE	6/19	5.0-380	25.7	380	85.8	67.0
BENZENE, HEXADECONE	3/18	15-39	8.63	39	9.27	13.2
TETRACHLOROETHENE	10/19	2.0-510	33.9	510	115	89.5
TOLUENE	13/19	4.0-1800	108	1800	410	305
ETHYLBENZENE	9/18	8.0-1000	65.3	1000	233	181
XYLENES (TOTAL)	9/18	18-7500	452	7500	1760	1328
PHENOL	1/16	1100-1100	284	1100	226	405
1,2-DICHLOROBENZENE	1/8	140-140	203	140	27.3	225
NAPHTHALENE	7/18	48-500	205	500	117	263
2-METHYLNAPHTHALENE	10/18	72-1200	318	1200	286	460
ACENAPHTHENE	7/18	64-420	212	420	101	262
DIBENZOFURAN	5/18	65-420	212	420	96.7	260
FLUORENE	6/18	100-420	236	420	95.7	284
PHENANTHRENE	13/18	89-2400	477	2400	533	742
ANTHRACENE	9/18	45-560	215	560	145	287
DI-N-BUTYLPHTHALATE	1/8	43-43	190	43	60.4	241
FLUORANTHENE	14/18	53-2500	455	2500	561	734
PYRENE	14/18	59-2300	401	2300	502	651
BENZO(a)ANTHRACENE	7/18	144-1000	267	1000	196	364
BIS(2-ETHYLHEXYL)PHTHALATE	6/18	88-1800	325	1800	380	514
CHRYSENE	10/18	91-1100	270	1100	232	385
BENZO(b)FLUORANTHENE	6/18	180-1100	288	1100	214	394
BENZO(k)FLUORANTHENE	5/18	110-610	237	610	115	294
BENZO(a)PYRENE	4/18	150-810	259	810	153	335
INDENO(1,2,3,c,d)PYRENE ..	2/18	81-560	239	560	105	291
BENZO(g,h,i)PERLYENE	3/18	82-520	234	520	99.4	284
AROCHLOR-1242	8/9	110-1600	356	1600	483	727
AROCHLOR-1260	8/9	31-240	79.6	240	69.2	133

LENZ OIL SITE
SOIL BORING INORGANICS
AREA A (MG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CADMIUM	14/24	0.71-2.6	1.01	2.6	0.554	1.24
CALCIUM	29/29	5860-137000	83297	137000	40940	98867
CHROMIUM (TOTAL)	29/29	5.2-97	42.9	97	20.8	50.8
COBALT	29/29	2.2-23	13.0	23	5.83	15.2
LEAD	29/29	16-909	385	909	243	477
POTASSIUM	28/29	521-9640	3055	9640	1782	3732
ZINC	29/29	21-639	266	639	153	324

LENZ OIL SITE
SURFACE SOIL ORGANICS
AREA B (UG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
METHYLENE CHLORIDE	2/19	6.0-11	8.15	11	4.49	10.3
ACETONE	6/19	8.0-270	40.4	270	73.3	75.7
1,1-DICHLOROETHANE	1/19	3.5-3.5	4.50	3.5	1.32	5.13
1,2-DICHLOROETHENE	1/11	7.0-7.0	5.86	7.0	0.452	6.16
1,2-DICHLOROETHANE	1/11	11-11	6.22	11	1.60	7.30
1,1,1-TRICHLOROETHANE	7/19	5.0-76	14.7	76	23.0	25.8
TRANS-1,3-DICHLOROPROPENE	3/19	7.0-7.0	5.21	7.0	1.44	5.90
TRICHLOROETHENE	5/19	3.0-220	16.3	220	49.3	40.1
BENZENE, HEXADECONE	1/19	11-11	5.07	11	1.90	5.99
4-METHYL-2-PENTANONE	1/11	7.0-7.0	5.81	7.0	0.462	6.12
TETRACHLOROETHENE	5/19	3.0-110	11.2	110	24.0	22.8
TOLUENE	6/19	3.0-18	5.31	18	3.37	6.94
ETHYLBENZENE	3/19	8.0-42	7.23	42	8.79	11.4
XYLENES (TOTAL)	2/19	28-100	10.7	100	22.3	21.5
NAPHTHALENE	1/16	82-82	192	82	31.9	209
2-METHYLNAPHTHALENE	4/16	67-77	166	77	57.1	196
ACENAPHTHENE	1/16	140-140	195	140	19.4	206
DIBENZOFURAN	1/16	120-120	194	120	23.5	207
FLUORENE	1/16	300-300	205	300	28.2	221
PHENANTHRENE	9/16	78-2000	303	2000	458	547
ANTHRACENE	4/16	31-660	203	660	134	275
FLUORANTHENE	10/16	110-3100	400	3100	729	788
PYRENE	11/16	97-2500	348	2500	582	658
BUTYL BENZYL PHTHALATE ...	2/16	0.000-330	195	330	62.9	229
BENZO(a)ANTHRACENE	4/16	89-1600	281	1600	353	469
BIS(2-ETHYLHEXYL)PHTHALATE	3/16	88-160	186	160	45.0	210
CHRYSENE	9/16	72-1500	254	1500	338	434
BENZO(b)FLUORANTHENE	3/16	120-1500	280	1500	327	454
BENZO(k)FLUORANTHENE	3/16	180-1400	275	1400	300	435
BENZO(a)PYRENE	1/16	1500-1500	281	1500	325	454
INDENO(1,2,3,c,d)PYRENE ..	3/16	180-610	225	610	104	280
BENZO(g,h,i)PERLYENE	2/16	210-650	227	650	113	288
GAMMA-BHC	1/9	1.3-1.3	1.45	1.3	1.29	2.45
ALDRIN	1/9	1.9-1.9	1.52	1.9	1.30	2.52
DDE	5/9	0.72-53	7.86	53	17.0	20.9
DDD	5/9	1.7-19	5.44	19	5.84	9.94
DDT	5/9	1.2-30	5.81	30	9.17	12.8
ALPHA CHLORDANE	2/9	3.0-3.7	1.95	3.7	1.51	3.11
GAMMA CHLORDANE	2/9	2.0-3.6	1.82	3.6	1.45	2.94
AROCHLOR-1242	1/9	330-330	62.0	330	104	142
AROCLOR-1254	1/9	90-90	35.3	90	32.4	60.2

LENZ OIL SITE
SURFACE SOIL INORGANICS
AREA B (MG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CADMIUM	2/41	1.7-1.9	0.600	1.9	0.646	1.03
CALCIUM	19/19	31600-133000	87695	133000	27903	101144
CHROMIUM (TOTAL)	19/19	6.6-52	27.3	52	12.3	33.3
LEAD	19/19	16-714	262	714	189	353
MAGNESIUM	19/19	17600-78400	47692	78400	18286	56506

LENZ OIL SITE
SOIL BORING ORGANICS
AREA B (UG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
METHYLENE CHLORIDE	8/36	4.0-21	8.33	21	6.87	10.5
ACETONE	14/36	8.0-450	63.0	450	104	97.1
1,1-DICHLOROETHANE	5/36	3.5-130	10.0	130	21.7	17.1
1,2-DICHLOROETHENE	1/22	7.0-7.0	7.76	7.0	6.81	10.7
CHLOROFORM	1/36	6.0-6.0	6.25	6.0	5.89	8.17
1,2-DICHLOROETHANE	1/22	11-11	7.94	11	6.84	10.9
1,1,1-TRICHLOROETHANE	17/36	5.0-160	18.6	160	32.2	29.1
TRANS-1,3-DICHLOROPROPENE	4/36	6.0-7.0	6.62	7.0	5.80	8.52
TRICHLOROETHENE	8/36	3.0-780	35.6	780	133	79.0
BENZENE, HEXADECONE	7/36	4.0-91	9.23	91	15.1	14.1
4-METHYL-2-PENTANONE	1/22	7.0-7.0	7.73	7.0	6.81	10.7
TETRACHLOROETHENE	9/36	3.0-2800	94.9	2800	466	247
TOLUENE	12/36	2.0-81	10.3	81	17.6	16.0
1,1,2,2-TETRACHLOROETHANE	1/22	24-24	7.95	24	7.32	11.2
ETHYLBENZENE	10/36	7.0-980	40.6	980	162	93.7
XYLENES (TOTAL)	9/36	4.0-2300	104	2300	395	233
NAPHTHALENE	3/29	58-240	194	240	38.8	208
2-METHYLNAPHTHALENE	7/29	61-640	199	640	98.7	237
ACENAPHTHENE	5/29	56-150	187	150	42.9	203
DIBENZOFURAN	3/29	44-120	189	120	42.8	205
FLUORENE	2/29	81-300	200	300	33.7	213
RENTACHLOROPHENOL	1/18	850-850	488	850	94.2	535
PHENANTHRENE	14/29	74-2000	375	2000	455	548
ANTHRACENE	6/29	65-660	202	660	96.9	239
DI-N-BUTYLPHTHALATE	2/18	169-280	197	280	24.2	209
FLUORANTHENE	13/29	103-3100	408	3100	615	642
PYRENE	15/29	97-2500	382	2500	505	574
BUTYL BENZYL PHTHALATE ...	3/29	0.000-1200	233	1200	192	306
BENZO(a)ANTHRACENE	8/29	89-1600	281	1600	277	386
BIS(2-ETHYLHEXYL)PHTHALATE	6/29	0.000-1800	257	1800	308	374
CHRYSENE	14/29	0.000-1500	252	1500	264	353
BENZO(b)FLUORANTHENE	7/29	0.000-1500	319	1500	361	457
BENZO(k)FLUORANTHENE	4/29	180-1400	243	1400	223	328
BENZO(a)PYRENE	5/29	86-1500	266	1500	250	361
INDENO(1,2,3,c,d)PYRENE ..	6/29	180-610	221	610	78.6	251
BENZO(g,h,i)PERLYENE	4/29	210-650	220	650	84.9	252
GAMMA-BHC	1/14	1.3-1.3	1.30	1.3	1.04	1.90
ALDRIN	2/14	1.8-1.9	1.38	1.9	1.06	1.99
DDE	5/14	0.72-53	5.76	53	13.6	13.6
DDD	5/14	1.7-19	4.21	19	4.89	7.04
DDT	5/14	1.2-30	4.45	30	7.44	8.74
ALPHA CHLORDANE	2/14	3.0-3.7	1.61	3.7	1.27	2.35
GAMMA CHLORDANE	2/14	2.0-3.6	1.53	3.6	1.20	2.23
AROCHLOR-1242	1/14	160-160	34.8	160	41.2	58.6
AROCLOR-1254	1/14	80-80	29.1	80	24.9	43.5

LENZ OIL SITE
SOIL BORING INORGANICS
AREA B (MG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CADMIUM	5/23	0.59-3.8	0.619	3.8	0.870	0.996
CALCIUM	33/33	19800-150000	86771	150000	38292	99836
LEAD	33/33	4.5-714	203	714	188	267
MAGNESIUM	33/33	10845-84400	46984	84400	22544	54676

LENZ OIL SITE
SURFACE WATER ORGANICS
DRAINAGE DITCH (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
PYRENE	1/5	2.0-2.0	4.40	2.0	1.34	6.06

LENZ OIL SITE
SURFACE WATER INORGANICS
DRAINAGE DITCH (UG/L)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
CADMIUM	1/5	20-20	4.57	20	8.63	15.2

LENZ OIL SITE
SEDIMENT ORGANICS
DRAINAGE DITCH (UG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
ACETONE	2/5	160-180	73.0	180	88.8	183
XYLENES (TOTAL)	1/5	10-10	5.60	10	2.58	8.80
NAPHTHALENE	1/5	1600-1600	586	1600	568	1291
2-METHYLNAPHTHALENE	1/5	460-460	358	460	65.7	440
ACENAPHTHENE	1/5	1600-1600	586	1600	568	1291
DIBENZOFURAN	1/5	1500-1500	566	1500	523	1215
FLUORENE	1/5	2200-2200	706	2200	836	1744
BUTYL BENZYL PHTHALATE ...	1/5	355-355	328	355	52.3	393
BIS(2-ETHYLHEXYL)PHTHALATE	5/5	210-730	452	730	227	734
BENZO(k)FLORANTHENE	5/5	355-2100	1471	2100	665	2296
BENZO(a)PYRENE	5/5	565-2700	1373	2700	813	2382

LENZ OIL SITE
SEDIMENT INORGANICS
DRAINAGE DITCH (MG/KG)

Parameter	Adjusted Detection Frequency	Range Low/high	Arithmetic Mean	Maximum Mean	Standard Deviation	Confidence Interval
COBALT	5/5	15-32	23.5	32	6.22	31.2
COPPER	5/5	59-140	106	140	34.1	148

APPENDIX D
ESTIMATION OF DILUTION FACTOR

APPENDIX D

ESTIMATION OF DILUTION FACTOR

INTRODUCTION

This appendix presents selected details about the fate and transport of a chemical contaminant from an unconfined aquifer to a surface stream. It uses a mass balance approach to estimate the dilution factor. The conceptual model is based on an assumption that contamination of the stream occurs as a result of interception of a steady-state groundwater plume.

MATHEMATICAL DESCRIPTION OF THE SURFACE WATER MODEL

The surface water model assumes interception of a contaminant plume by a stream perpendicular to the groundwater gradient. Further, it is assumed that at the downstream edge of the near-field mixing region, the river is laterally as well as vertically mixed. With these assumptions, the following mass balance equation can be written:

$$M_g = C_s (Q_g + Q_s) \quad (D-1)$$

where

- M_g = contaminant mass flux entering the stream [g/sec]
- C_s = the near-field fully mixed contaminant concentration in the stream [g/m^3 or mg/L]
- Q_g = groundwater discharge to stream [m^3/sec]
- Q_s = stream discharge [m^3/sec]

The stream discharge is obtained from stream flow records (USGS 1991).

$$Q_g = V_s \theta H W \quad (D-2)$$

where

- V_s = the steady-state, horizontal seepage velocity in the aquifer [m/yr]
- θ = effective soil porosity
- H = depth of plume captured by the river [m]
- W = width of the source parallel to stream flow direction [m]

Equation D-2 calculates the volumetric flow from the groundwater, Q_g , using a steady-state seepage velocity and an estimate of the cross-sectional area of the plume that intercepts the

stream. The conservative assumption is made that no retardation occurs. The model also assumes that no lateral or vertical dispersion of the plume occurs under uniform flow conditions.

The mass flow rate of contaminant, M_g , in the aquifer is estimated as:

$$M_g = C_g Q_g \quad (D-3)$$

C_g = contaminant concentration in ground water [g/m^3 or mg/L]

A mass balance on the flow rate of contaminants in the aquifer and in the river can be performed to obtain a dilution ratio. Assuming that no degradation of contaminants occurs in either the surficial aquifer or in the river during mixing, and assuming that the stream is not contaminated before passing the site, the dilution factor relating stream and groundwater concentrations is given as:

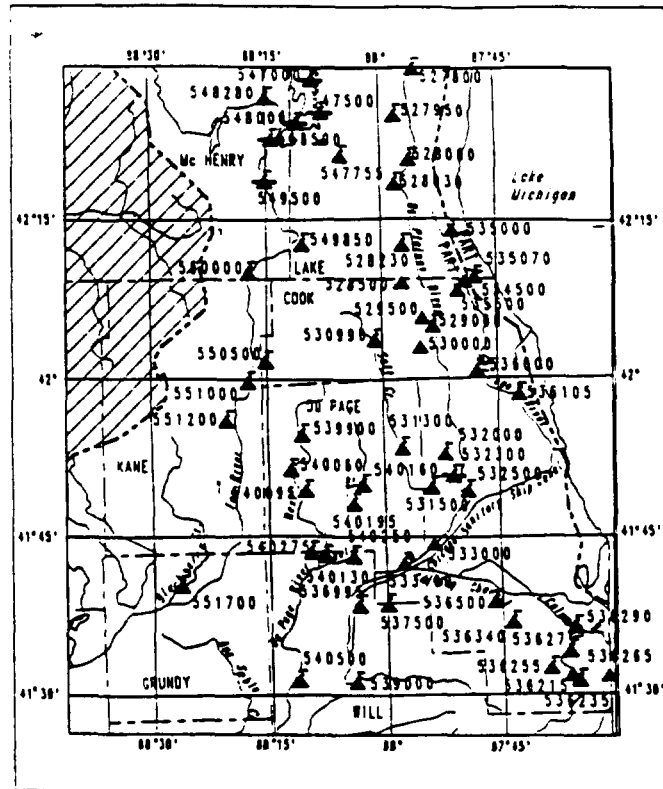
$$C_s/C_g = Q_g / (Q_g + Q_s) \quad (D-4)$$

APPLICATION OF MODEL

The following calculations provide an estimate of the dilution factor based on conservative assumptions for the aquifer and river parameters downgradient from the Lenz Oil site. English units are used throughout. As shown in Figure D-1, the nearest surface water gaging station 532500 is approximately 15 miles upstream from the site. Flow rates shown on Figure D-2 for the period October 1990 through September 1991 for that station show that the minimum flow rate was 140 cubic feet per second (cfs) on July 6. In the absence of surface water data for other years, this minimum value will be assumed to be appropriate for the stream flow rate, Q_s .

From Figure D-3, which shows the extent of groundwater contamination at the site, the width of the plume, W , is estimated to be 500 feet.

From page 3-9 of the Lenz Oil site RI/FS technical memorandum No. 3A (ERM 1992), the average horizontal groundwater velocity, V_g , through the unconsolidated surficial part of the aquifer is 12.69 feet per day and the effective porosity, θ , is equal to 0.25. Caution regarding the interpretation of results needs to be exercised since the report also indicates that flow through the dolomite in the unconsolidated aquifer cannot be estimated. The technical memo (ERM 1992) reports that the unconsolidated material thins as it approaches the river. For purposes of estimating the dilution factor, the velocity, V_g , is assumed to be equal to 13 feet per year. This



Base from U.S. Geological Survey
1:250,000 and 1:1,000,000 Digital Line Graphs
Albers Equal-area Conic Projection
Standard parallels 33° and 44°, central meridian -98°

0 5 10 15 MILES
0 5 10 15 KILOMETERS

EXPLANATION

- Basin boundary (surface water)
- Continuous record station
- Continuous record, stage only
- Continuous record with telecommunication

586690 Station number (see note)

Note: The number on the map is the station number; the part number prefix has been omitted. The part number is 03 for streams tributary to the Ohio River basin; 04 for streams tributary to the St. Lawrence River basin; 05 for streams tributary to the Upper Mississippi River basin; and 07 for streams tributary to the Lower Mississippi River basin.

Figure 8.--Location of active surface-water gaging stations in northeastern Illinois.

FIGURE D-1 ACTIVE SURFACE WATER GAGING STATIONS IN NORTHEASTERN ILLINOIS

Source: USGS 1991

PRC Environmental Management, Inc.

ILLINOIS RIVER BASIN

05532500 DES PLAINES RIVER AT RIVERSIDE, IL

LOCATION---Lat 41°49'20", Long 87°49'15", in SW1/4SW1/4 sec.36, T.39 N., R.12 E., Cook County, Hydrologic Unit 07120004, on left bank 400 ft downstream from bridge on Barry Point Road in Riverside, 500 ft downstream from Hoffman Dam, 4,000 ft downstream from Salt Creek, and at mile 44.3.

DRAINAGE AREA---630 mi².

WATER-DISCHARGE RECORDS

PERIOD OF RECORD---October 1943 to current year. Monthly discharge only for some periods, published in WSP 1308.

REVISED RECORDS---WSP 1174: 1944, 1948. WSP 1308: 1944(M). WDR IL-75-1: Drainage area.

GAGE---Water-stage recorder and concrete dam. Datum of gage is 594.68 ft above National Geodetic Vertical Datum of 1929. Prior to Nov. 27, 1946, nonrecording gage at bridge 400 ft upstream at same datum.

REMARKS---Water-discharge records good except those for estimated daily discharges, which are poor. Occasional regulation by gates at Hoffman Dam. U.S. Army Corps of Engineers satellite telemeter at station.

EXTREMES OUTSIDE PERIOD OF RECORD---Flood of Mar. 18, 1919, reached a discharge of 7,450 ft³/s, from information furnished by Metropolitan Sanitary District of Greater Chicago.

EXTREMES FOR CURRENT YEAR---Maximum discharge, 5,270 ft³/s, Nov. 28, gage height, 7.40 ft; minimum daily, 140 ft³/s, Aug. 5, 6.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	207	266	2120	798	277	494	1720	796	918	169	151	165
2	212	257	1460	788	325	1120	1650	692	974	166	149	146
3	241	252	1510	e600	403	1120	1600	626	915	219	156	425
4	216	376	1610	e520	766	937	1570	585	788	323	145	698
5	274	2370	1340	e500	1180	819	1490	1230	655	212	140	327
6	233	2800	1150	e400	1180	769	1310	1420	572	173	140	237
7	355	2190	1030	e380	1100	739	1160	983	499	360	152	190
8	601	1470	937	e370	1010	684	1050	787	429	348	1010	164
9	1630	1100	853	e360	981	662	2450	689	381	237	934	171
10	2130	959	803	e350	986	591	2690	627	348	204	469	322
11	2010	920	774	367	950	535	2250	584	778	185	298	191
12	1370	852	745	396	867	633	1730	537	528	178	236	505
13	926	792	728	399	802	634	1390	494	380	166	208	621
14	775	761	709	392	758	654	1590	469	335	153	194	554
15	930	721	759	415	648	704	3790	434	395	152	181	615
16	720	686	780	971	406	713	4140	644	398	159	176	440
17	647	616	790	1020	508	873	3630	870	329	155	170	311
18	1010	547	875	697	776	1650	2850	957	292	153	184	261
19	790	483	845	605	1090	1470	2220	623	265	151	319	231
20	640	446	796	e630	909	1180	1830	498	249	147	247	193
21	543	557	843	e520	804	989	1660	445	237	148	180	172
22	491	577	865	e460	819	888	1520	421	223	204	164	168
23	449	459	742	e420	782	1010	1410	827	218	339	156	167
24	413	415	547	e370	719	889	1420	740	212	189	148	184
25	381	399	471	e340	648	764	1260	1540	210	151	144	219
26	355	379	493	e340	583	1080	1100	2660	199	147	147	188
27	322	1770	479	342	522	1900	1060	2190	195	143	152	167
28	302	5030	524	328	478	2540	1040	1910	188	153	154	161
29	286	4360	1460	316	---	2370	993	1320	185	148	202	150
30	283	3320	1550	296	---	2060	915	1000	172	160	625	152
31	277	---	1050	268	---	1830	---	1000	---	168	259	---
TOTAL	20219	36130	29638	14960	21277	33303	54488	28598	12467	5960	7990	8495
MEAN	652	1204	956	483	760	1074	1816	923	416	192	258	285
MAX	2130	5030	2120	1020	1180	2540	4140	2660	974	360	1010	698
MIN	207	252	471	268	277	494	915	421	172	143	140	146
CFSM	1.04	1.91	1.52	.77	1.21	1.71	2.88	1.46	.66	.31	.41	.45
IN.	1.19	2.13	1.75	.88	1.26	1.97	3.22	1.69	.74	.35	.47	.50

e Estimated

FIGURE D-2

WATER DISCHARGE RECORDS FOR
GAGING LOCATION 05532500
DES PLAINES RIVER AT
RIVERSIDE, ILLINOIS

Source: USGS 1991

PRC Environmental Management, Inc.

estimate may be too low if the flow rate through the dolomite is much higher than the flow through the unconsolidated material.

No data are available on the thickness of the aquifer intercepted by the river. As a conservative estimate, the thickness, \tilde{L} , is assumed to be 20 feet.

The estimated flow rate from the aquifer, Q_g , is estimated as:

$$Q_g = (13 \times 0.25 \times 500 \times 20) \text{ ft}^3/\text{day} / ((24)(3600)) \text{ sec/day} \quad -$$

$$Q_g = 0.38 \text{ cfs}$$

This flow rate from the aquifer can be used to estimate the dilution factor using equation D-4.

$$C_s/C_g = 0.38 / (140 + .38) = 0.0027 = 1/369$$

RECOMMENDATION

Although many of the assumptions stated above are only approximations, the analysis suggests that a dilution of factor of 1/400 or 0.025 is a reasonable value to use when assessing risk to biota in the stream.

REFERENCES

ERM 1992. Technical Memorandum No. 3A, Remedial Investigation, Phase I, Task 2, Lenz Oil Services, Inc., Lemont, Illinois, Volume 3 of 3. Environmental Resources Management - North Central, Inc. January 5, 1992.

USGS 1991. Water Resources Data Illinois Water Year - 1991. Volume 2 Illinois River Basin. U.S. Geological Survey, Water-Data Report IL-91-2.

APPENDIX E
ESTIMATION OF PARTICULATE EMISSIONS

APPENDIX E

ESTIMATION OF PARTICULATE EMISSIONS

A conservative model for estimating particulate concentrations in air is provided by Cowherd (1985). This model calculates a particulate emission factor (PEF), which is then used to convert soil concentrations to air concentrations. The following assumptions are implicit in this model: (1) contaminant concentrations of particles suspended in air equal measured concentrations in soil; (2) particle emissions to air occur at a steady rate; (3) soil concentrations do not change over time (for example, from volatilization or chemical reaction); and (4) both the 95 percent upper confidence limit and the maximum contaminant concentration observed were provided in the soil concentration data. The lesser of these two concentrations was used in to calculate concentrations in air.

Once concentrations are calculated, the following assumptions are used to calculate risk:

- Standard default risk parameters for a resident child were used to calculate either risk or a hazard quotient for each compound.
- The screening levels were either a 10^{-7} excess lifetime cancer risk or a 0.1 hazard quotient for each compound tested. Compounds showing less risk than this are eliminated from further consideration.

Data were divided into two major areas: the excavated area and the unexcavated area. Data for surface soils only were used in these calculations.

The Cowherd (1985) model was used to determine an emission rate (E_{10}), which is then used to calculate the PEF and finally the risk or hazard quotient in the manner described by the U.S. Environmental Protection Agency (EPA) (1991). Site-specific parameters and local wind conditions are used in these calculations. Once the PEF is obtained, it is used to convert soil concentrations to air concentrations. These concentrations are used in the standard risk equations.

The method for calculating E_{10} is fairly detailed, and several assumptions and estimates are required. Reasonably conservative assumptions and estimates were used, as described in Cowherd (1985). The primary assumptions are that the site is dry and exposed to wind. Cowherd (1985)

states clearly that this method should be used to provide an order-of magnitude estimate of risk. With site-specific information, one would expect an estimate of risk using this method to be within an order of magnitude. Unfortunately, site-specific information is not readily available for this site; estimates will be used.

The first estimate is to obtain the aggregate size distribution mode of the surface soil. Ideally, the soil should be tested; however, a rough estimate may be made based on the type of soil present. The surface soils described are Sawmill silty clay loam and Kane silt loam; these soils tend to be both silty and loamy. The size range of silts is 0.004 to 0.063 millimeters (mm) (Driscoll 1986); silts present the greater risk of suspension. Clays present a smaller grain size, but tend to form crusts, which tend not to erode and hence present less risk. Cowherd (1985) presents a graph that relates grain size to threshold friction velocity ($u_{*,th}$), although the lowest aggregate size distribution mode presented is 0.1 mm. By extrapolating from this graph, $u_{*,th}$ is estimated to be 15 cm/sec.

A correction to this estimate is appropriate because photographs of the site show that these soils contain cobbles. This correction accounts for the fraction of the surface that is nonerodible because of grains, such as cobbles, that are larger than 1 centimeter. By comparing the photographs of the Lenz Oil site with photographs in the Cowherd document (1985), a conservative correction factor of 2 is applied, creating a corrected $u_{*,th}$ of 30 centimeters per second (cm/sec).

The second estimate regards the roughness height (z_o). The roughness height describes the local terrain, such as the roughness of the ground and the presence or absence of local buildings. Increasing this factor will increase air turbulence at the site, which has the net effect of decreasing the threshold friction velocity as measured at 7 meters (u_{7m}). This is the typical weather station sensor height. A loose, exposed soil, such as may be found in a plowed field, is hypothesized for this site. The roughness height is estimated as approximately 1 centimeter.

The $u_{*,th}$, z_o , and u_{7m} are related to each other as shown by Equation E-1.

$$u_{7m} = 2.5 \times u_{*,th} \times \ln(700 \text{ cm}/z_o) \quad (\text{E-1})$$

where

z_o	=	roughness height (cm)
u_{7m}	=	threshold windspeed at 7 meters (m/sec)
$u_{*,th}$	=	threshold friction velocity (m/sec)
\ln	=	natural logarithm function

Using equation 1, u_{7m} is calculated as 4.92 meters per second (m/sec).

The third estimate regards the degree to which the site is vegetated. The fraction of vegetative cover (V) is estimated, and used directly in the equation to calculate E_{10} . The greater the degree of vegetation, the less the opportunity for particles to suspend in air. This fraction ranges from 0 to 1.0; V is conservatively estimated as 0.9 for the unexcavated portion and as 0.1 for the excavated portion.

Finally, equation E-2 shows the method by which E_{10} is calculated. This equation assumes that the soil has an unlimited erosion potential. An unlimited erosion potential implies that there is little tendency to form crusts on the surface, which would limit erosion. Silty soil will exhibit some of this characteristic, the degree is unknown. Therefore, the equation for E_{10} describing unlimited erosion potential is used.

$$E_{10} = 0.036 * (1 - V) * ([u] / u_{7m})^3 * F(x) \quad (\text{E-2})$$

where

E_{10}	=	PM_{10} emission rate (g/m^2 -hr); (PM_{10} represents the soil fraction with diameter less than or equal to 10 microns.)
V	=	fraction of vegetative cover (unitless)

- [u] = mean annual windspeed [4.6 m/sec for Chicago (Cowherd 1985)]
- u_{7m} = threshold windspeed at 7 meters (calculated earlier as 4.91 m/s)
- $F(x)$ = function plotted by Cowherd (1985)

Using Equation E-2 with the assumptions provided above, x is calculated as 0.95, and $F(x)$ is estimated as 1.65, according to Cowherd (1985). Finally, E_{10} is calculated as 0.044 g/m²-hr for the excavated portion, and 0.005 g/m²-hr for the unexcavated portion.

The PEF is then calculated from E_{10} using EPA guidance (EPA, 1991). The PEF is used in the risk calculation and assumes a box model. This model assumes a steady emission rate from the soil into the box, a steady flow of clean air into one side of the box, and a steady exit flow of air out the opposite end of the box. A mass balance is then used to calculate the concentration in the box. This is a conservative model.

The EPA guidance considers the size of the site, the diffusion height, and the windspeed in the mixing zone (EPA, 1991). The windspeed in the mixing zone is assumed equal to the mean annual windspeed of 4.6 m/sec, and the default value for the diffusion height is used. The size of the site is measured from the map provided. This map divides the site into the two areas, the excavated area and the unexcavated area. Equation E-3 shows the formula for calculating PEF:

$$PEF = \frac{LS \times V \times DH \times 3,600 \text{ sec/hr} \times 1,000 \text{ g/kg}}{A \times E_{10}} \quad (E-3)$$

where

- PEF = particulate emission factor (m³/kg)
- LS = width of the contaminated area (m)
- V = mean annual windspeed (m/s)
- DH = diffusion height (conservatively estimated as 2 m)
- A = contaminated area (m²)
- E_{10} = emission rates (calculated in Equation 2)

For the excavated area, LS is 58 m and A is 5,300 m². Therefore, PEF is calculated as 8.2 x 10⁶ m³/kg for the excavated area.

For the unexcavated area, LS is 106 m and A is 17,200 m². Therefore, PEF is calculated as 4.1 x 10⁷ m³/kg.

PEF is used in standard risk equations. By dividing the soil concentration (mg/kg) for a given compound by the PEF (m³/kg), an air concentration (mg/m³) is estimated. This air concentration is used to calculate risk from particulate inhalation.

The Cowherd (1985) method combined with the method described by EPA (1991) is detailed, but provides an order of magnitude estimate of risk. An advantage to using Cowherd (1985) is that additional site-specific data allows further refinements to this estimate.

Uncertainties in using this model come from the following sources:

- Measured concentrations in soil (mg/kg), were used to calculate a 95 percent upper confidence limit. This 95 percent upper confidence limit was compared to the measured maximum, and the lower of the two values was used. While this is believed to be adequately conservative, an uncertainty is inherent in this method.
- Particulate emissions to air are assumed to occur at a steady rate. The wind is the force causing suspension, and particulate suspension will vary with windspeed. The Cowherd (1985) model is believed to be conservative.
- Soil concentrations are assumed to be constant. No allowance is made for decreases in soil concentrations because of biodegradation, volatilization, chemical reaction, dispersion, or for any other cause. This is conservative.
- Concentrations of contaminant in suspended particulates (mg/kg) are assumed to equal measured soil concentrations. In other words, measured soil contaminant concentrations are in units of mg/kg, and particulate contaminant concentrations are assumed to equal these measured values. Some contaminants may selectively bind to smaller, more easily suspended soil particles, making this nonconservative. However, this type of binding is not readily estimated. Hence, this assumption is used.
- The aggregate size distribution mode for the soil was estimated from photographs of the site and soil description. A silty soil was assumed, and the size range of silts was assumed as the size distribution mode. This is conservative.
- The surface silt is not assumed to form crusts, which decreases suspension in air. This is conservative.
- The correction factor applied to the threshold wind speed is conservative.

- The roughness height is conservative; loose, exposed soil is assumed.
- The degree of vegetation on site is conservatively overestimated from site photographs.
- A box model is assumed in calculating air concentrations. This is a conservative assumption.
- The diffusion height is 2 meters, which is the standard conservative assumption.

Most of the factors listed above are estimated conservatively, so that the air concentrations may be somewhat overestimated. The single exception is the capacity for a given contaminant to bind selectively to suspendable particles in soil, which is an unknown.

REFERENCES

Cowherd, C. 1985. Rapid Assessment of Exposure to Particulate Emissions for Surface Contamination Sites. EPA/600/8-85/002, U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. February 1985.

EPA 1991. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Publication 9285.7-01-B. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 1991.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division.

APPENDIX F
ESTIMATION OF VOLATILE EMISSIONS

APPENDIX F

ESTIMATION OF VOLATILE EMISSIONS

This appendix describes the process for calculating the air concentration at the receptor. Three basic steps are required. First, soil gas concentrations are determined from given soil concentrations. Second, the Farmer model (EPA 1988b) is used to estimate emission rates to the surface. Third, a dispersion model provided by EPA (1988a), SCREEN, is used to estimate concentrations at the house nearest to the site. Several assumptions are required at each step.

First, soil gas concentrations must be estimated from known soil concentrations for each contaminant of concern. One of two methods is used for this calculation. An explanation of each equation is followed by a description of the method used to choose which equation to use.

Estimation of soil gas concentrations based on the saturation vapor pressure assumes that enough contaminant exists in the soil matrix to produce a soil gas concentration equivalent to the saturation vapor pressure. Equation F-1 shows the calculation of soil gas concentration from vapor pressure:

$$SGC = \frac{P \times MW}{R \times T} \quad (F-1)$$

where

SGC	=	soil gas concentration, in grams per cubic meter (g/m ³)
MW	=	molecular weight for a compound, in grams per mole (g/mol)
P	=	vapor pressure of the compound, in Pascals (Pa)
R	=	8.31451 cubic meters-Pascals per mole-Kelvin (m ³ -Pa/mol-K)
T	=	temperature at a given soil depth (estimated as 298 K)

Saturation vapor pressure was estimated in some cases, either using methods suggested by Lyman et al. (1990) or using conservative estimates.

However, in cases where concentrations of a given contaminant are low, saturation vapor pressure will not be achieved in the soil gas, even if complete volatilization occurs. In these cases, soil gasses are calculated on the assumption that a given contaminant volatilized completely into the soil gas. Since measured concentrations are available, this may be calculated if soil density and

porosity are assumed. Equation (F-2) shows the calculation of maximum soil gas concentrations, given an overall soil concentration:

$$SGC = \frac{C \times \rho \times 10^6 \text{ cm}^3/\text{m}^3}{10^3 \text{ g/kg} \times P_t \times 10^6 \text{ } \mu\text{g/g}} \quad (F-2)$$

where: SGC = soil gas concentration, in grams per cubic meter (g/m³)
 C = measured overall soil concentration, as $\mu\text{g/kg}$
 ρ = soil density, assumed to be 2.65 g/cm³
 P_t = soil porosity, assumed to be 0.35 m³ air/m³ total soil volume

The equation producing the more appropriate soil gas concentration was used; this will always be the equation producing the smaller soil gas concentration. The reason for this follows. The determination of whether equation F-1 or F-2 is more accurate is based on whether or not saturation vapor pressure can be achieved if the contaminant volatilizes completely.

If saturation vapor pressure can be achieved, then Equation F-1 will produce a lesser result than Equation F-2, but Equation F-1 will produce the maximum soil gas concentration that is possible. On the other hand, if all of the contaminant volatilizes, and saturation vapor pressure is not achieved in the soil gas matrix, then Equation F-2 will produce the lesser result, but it generates the maximum soil gas concentration which is possible.

Hence, in choosing between Equation F-1 and F-2, the equation producing the lesser result is most appropriate.

Second, emission rates for each compound to the surface must be calculated. EPA (1988b) describes the Farmer model for estimating emission rates to the surface. This model assumes completely dry soil and a zero concentration at the surface. These are both worst-case assumptions. Two further assumptions that are applied to this equation include: (1) the mole fraction of a given compound in the waste is 100 percent, which is conservative; and (2) a depth

for the observed contamination is assumed to equal 1 foot. The second assumption is extremely conservative in some cases. Since this factor is unknown, an acceptably conservative assumption will be extremely conservative. Equation F-3 shows this model, including the additional assumptions:

$$E = D \times SGC \times P_t^{4/3} / d \quad (F-3)$$

where

E	=	emission rate for a component, in grams per second per square centimeter (g/s-cm ²)
D	=	diffusion coefficient in air for a component in square centimeters per second (cm ² /s)
SGC	=	soil gas concentration, in grams per cubic centimeter (g/cm ³)
P _t	=	total soil porosity, assumed to equal 0.35 (dimensionless)
d	=	depth to contamination, assumed to equal 1 foot (30.5 cm)

Diffusion coefficients are either obtained directly from EPA (1988b), estimated using the method described by EPA (1988b), or conservatively estimated.

Once emission rates have been determined, contaminant air concentrations downwind are estimated using the SCREEN model described by EPA (1988a). These airborne contaminant concentrations are calculated at various locations, each a different distance from the contaminated soil. For the excavated area, the nearest house is 120 feet away; for the unexcavated area, the nearest house is 60 feet away. This model is available on disk and describes air quality impact from stationary sources.

Uncertainty for assumptions made in these models include the following:

- Estimation of soil gas concentrations from equations F-1 or F-2 is conservative. Because both describe the upper possible limit, the equation calculating the lesser amount is still conservative.

- The Farmer model (EPA 1988b) assumes a completely dry soil in the calculation of emission rates. This is as conservative as possible.
- The Farmer model (EPA 1988b) also assumes zero concentration at the surface to calculate emission rates. This is as conservative as possible.
- The Farmer model (EPA 1988b) assumes a mole fraction of 100 percent in its calculation of emission rates. This is as conservative as possible.
- The depth of contamination for the Farmer model (EPA 1988b) is 1 foot. Because the depth of sampling was variable and difficult to correlate for a specific datum, the estimate of one foot was used. This is believed to be adequately conservative, since most samples were collected from greater depths.
- The dispersion model used assumes a Gaussian-type dispersion with site-specific data. This type of model is believed to provide a conservative order-of-magnitude approximation of air concentrations.

Because all of the factors contributing to uncertainty are conservatively estimated, the air concentrations generated using this method are likely overestimated. In the event that inhalation risks calculated based on these air concentrations are significant, several options are possible to ascertain these concentrations. One option is to test emissions flux at the site; another option is to test soil gas concentrations; a third option is to test air ambient concentrations either at the site or at the site boundary. If any of these options are pursued, the results could be used to adjust the models.

REFERENCES

Lyman, Warren J., William F. Reeh, and David H. Rosenblatt. 1990. Handbook of Chemical Property Estimation Methods. American Chemical Society, Washington D.C.

EPA 1988a. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources. EPA-450/4-88-010; PC-compatible model. U.S. Environmental Protection Agency.

EPA 1988b. Superfund Exposure Assessment Manual. EPA/540/1-88/001. U.S. Environmental Protection Agency. April 1988.

APPENDIX G
ESTIMATION OF VOLATILE EMISSIONS DURING SHOWERING

APPENDIX G

ESTIMATION OF VOLATILE EMISSIONS DURING SHOWERING

Inhalation exposures to volatile organic compounds (VOCs) during showering were calculated based on the model developed by Foster and Chrostowski (1987). This model assumes that a certain percentage of VOCs are released into the air during showering, and incorporates many of the factors that influence the release of VOCs during showering and the buildup of these VOCs in the shower room air.

Inhalation exposures to VOCs depend on three factors: (1) the rate of chemical release into the air; (2) the buildup and decay of VOCs in the shower room air; and (3) the rate and direction of inhalation while the shower is on and after the shower has been turned off.

The rate of VOC release into the air was estimated by adapting the two-film gas-liquid mass transfer theory proposed by Liss and Slater (1974). This theory describes the estimation of the overall mass transfer coefficient (K_L) for each VOC of interest, according to equation G-1:

$$K_L = (1/K_1 + RT/H K_g)^{-1} \quad (G-1)$$

where:

- K_L = Overall mass transfer coefficient (cm/hr)
- H = Henry's Law constant (atm-m³/mol-K)
- RT = 2.4E-02 atm-m³/mole (gas constant of 8.2E-05 atm-m³/mol - K times absolute temperature of 293 ° Kelvin)
- K_g = Gas-film mass transfer coefficient (cm/hr), and
- K_1 = Liquid-film mass transfer coefficient (cm/hr)

Typical values of K_1 (20 cm/hr) for carbon dioxide (CO₂) and K_g (3,000 cm/hr) for water (H₂O) may be used to estimate VOC-specific K_1 and K_g values (Liss and Slater 1974):

$$K_g (\text{VOC}) = K_g (\text{H}_2\text{O}) (MW_{\text{H}_2\text{O}} / MW_{\text{VOC}})^{0.5} \quad (G-2)$$

$$K_1 (\text{VOC}) = K_1 (\text{CO}_2) (MW_{\text{CO}_2} / MW_{\text{VOC}})^{0.5} \quad (G-3)$$

where:

- VOC = Volatile organic compound of concern
- MW_{VOC} = Molecular weight (g/mole) of the VOC

$$MW_{H_2O} = 18$$

$$MW_{CO_2} = 44$$

The mass transfer coefficient, K_L , is adjusted to the shower water temperature, T_s , according to equation G-4 (O'Connor and Dobbins 1977):

$$K_{sL} = K_L (T_1 \mu_s / T_s \mu_1)^{-0.5} \quad (G-4)$$

where:

$$K_{sL} = \text{Adjusted overall mass transfer coefficient (cm/hr)}$$

$$T_1 = \text{Calibration water temperature of } K_L \text{ (°Kelvin)}$$

$$T_s = \text{Shower water temperature (°Kelvin)}$$

$$\mu_1 = \text{Water viscosity at } T_1 \text{ (Cp)}$$

$$\mu_s = \text{Water viscosity at } T_s \text{ (Cp)}$$

The VOC concentration leaving the shower droplet, C_{wd} , is determined from equation G-5:

$$C_{wd} = C_{wo} (1 - \exp [-K_{sL} ts / 60d]) \quad (G-5)$$

where:

$$C_{wd} = \text{Concentration leaving the shower droplet after time } ts \text{ (}\mu\text{g/L)}$$

$$C_{wo} = \text{Shower water concentration (}\mu\text{g/L)}$$

$$d = \text{Shower droplet diameter (mm)}$$

$$ts = \text{Shower droplet drop time (sec)}$$

The value $1/60d$ equals the specific interfacial area, $6/d$, for a spherical droplet of diameter (d) in mm, multiplied by conversion factors (hr/3,600 sec and 10 mm/cm).

Equation G-5 assumes that the shower water breaks up into droplets of equal size and that volatilization occurs only from the time the droplet is formed until it reaches the shower bottom. Furthermore, the model does not account for volatilization from the water layers formed as the shower water runs over an individual or for the additional volatilization as water runs out of the bottom of the shower. This model is therefore more likely to underestimate than overestimate VOC emissions and exposures.

The VOC generation rate in the shower room can be calculated from equation G-6:

$$S = C_{\text{vd}} (\text{FR}) / \text{SV} \quad (\text{G-6})$$

where:

$$\begin{aligned} S &= \text{Indoor VOC generation rate } (\mu\text{g}/\text{m}^3 - \text{min}) \\ \text{FR} &= \text{Shower water flow rate (L/min)} \\ \text{SV} &= \text{Shower room air volume (m}^3\text{)} \end{aligned}$$

A one-box indoor air pollution model is used to estimate VOC air concentrations in the shower room. This model can be expressed as a differential equation:

$$d \text{ Ca}/dt = -R\text{Ca} + S \quad (\text{G-7})$$

where:

$$\begin{aligned} \text{Ca} &= \text{Indoor VOC air concentration } (\mu\text{g}/\text{m}^3) \\ R &= \text{Air exchange rate (min}^{-1}\text{)} \end{aligned}$$

It should be noted that this model assumes instantaneous mixing of the shower room air and no chemical decay of VOCs once they are released. However, air concentrations may be higher near the shower head, and therefore within the individual's breathing zone; VOCs may decay upon release.

When equation G-7 is integrated, the time-dependent indoor concentration is estimated as:

$$\text{Ca}(z) = (S/R) (1 - \exp [-Rt]) \text{ for } t \leq D_s \quad (\text{G-8})$$

and

$$\text{Ca}(t) = (S/R) (\exp [RD_s] - 1) \exp (-Rt) \text{ for } t > D_s$$

where:

$$\begin{aligned} \text{Ca}(t) &= \text{Indoor air VOC concentration at time } t (\mu\text{g}/\text{m}^3) \\ D_s &= \text{Shower duration (min)} \\ t &= \text{Time (min)} \end{aligned}$$

The average inhaled concentration during the shower can then be calculated according to the equation:

$$C_a = [S/(R^2 D_t)] \int_0^{D_t} \text{Ca}(t) dt \quad (\text{G-9})$$

where:

$$C_a = \text{Average inhaled concentration while in the shower room } (\mu\text{g}/\text{m}^3)$$

D_t = Total duration in the shower room (min)

This equation can be solved as:

$$C_s = [S/(R^2 D_t)] \times [D_s R + \exp(-R D_t) - \exp(R(D_s - D_t))] \quad (G-10)$$

for both the duration of the shower and the duration in the shower room after the shower is turned off.

For the purposes of this risk assessment, exposures were calculated using a residential exposure scenario for a child.

TABLE G-1
INPUT PARAMETERS FOR THE SHOWER MODEL

Parameter	Value
Shower water temperature (T_s)	45° C (318K)
Calibration water temperature (T_1)	25° C (298k)
Water viscosity at T_s (μ_s)	0.596 cp
Water viscosity at T_1 (μ_1)	1.000 cp
Shower water flow rate (FR)	10 L/min
Droplet diameter (d)	1 mm
Droplet drop time (ts)	2 sec
Air exchange rate (R)	30 min ⁻¹ (probable case) 90 min ⁻¹ (RME case)
Shower room air volume (SV)	6 m ³
Shower duration (Ds)	10 minutes (probable case) 15 minutes (RME case)
Duration in room after shower is turned off (Da)	5 minutes
Total duration in the shower room (min)	$D_s + D_a$
Body weight (Kg)	15 kg (children) and 70 kg (adult)

REFERENCES

Foster, Sarah A., and Paul C. Chrostowski, 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower. Presented at the 80th Annual Meeting of APCA, June 21-26, 1987.

Liss, P. S., and P. G. Slafer, 1974. Flux of Gases Across the Air-Sea Interface. *Nature*, 247: 181-184.

O'Connor, D. J., and W. Dobbins, 1977. The Mechanics of Reaeration in Natural Streams. *J. Sanit. Eng. Div., ASCE* 82: SA6.

APPENDIX H
TOXICOLOGICAL PROFILES

Cadmium

Cadmium has long been recognized as a toxic substance, and its toxicity has been repeatedly reviewed. Some of these reviews (Stokinger, 1981; Carson and others, 1986; Goyer, 1986) form the basis of this summary.

The extent to which cadmium compounds are absorbed depends on their solubility. Typically, about 5 percent of an oral dose is absorbed. However, various dietary factors such as calcium and iron deficiencies may stimulate absorption. Cadmium concentrates in the liver and kidneys. Excretion via the urine is very slow; the biologic half-life of cadmium has been estimated to be between 19 and 38 years.

The acute toxic effects of cadmium are primarily local irritation. Oral doses produce nausea, vomiting, salivation, diarrhea, and abdominal cramps. Immediate death may be caused by shock and dehydration; renal and cardiopulmonary failure may cause death a week or so after ingestion. Several epidemics of gastro intestinal distress have resulted when cadmium leached from ceramic containers of acid media such as fruit juices. Zinc and selenium can counteract cadmium toxicity.

Chronic toxicity has been seen primarily in workers exposed to cadmium fumes and dusts, and in Japanese villagers who drank cadmium-contaminated water and ate rice grown in that water. The Japanese villagers had extensive kidney damage. Symptoms initially noted as severe joint and muscle pains (hence the name "itai-itai" or "ouch-ouch" disease) progressed to osteomalacia with consequent multiple fractures. Menopause and dietary deficiencies may have aggravated the effects of the cadmium toxicity.

The carcinogenicity of cadmium has been disputed, with much recent research resulting in changed conclusions (see documents by IARC, 1973, 1976, and 1982; and U.S. EPA, 1985c). Epidemiologic studies have shown limited evidence of lung and other cancers after inhalation exposure; therefore, cadmium is classified by U.S. EPA as a probable human carcinogen. No animal studies have found cadmium to be carcinogenic after ingestion. If cadmium is carcinogenic after ingestion, its potency is no more than 1/100 that of inhalation.

Parenteral doses of cadmium have been shown to decrease testosterone levels and produce adverse effects on the testes and prostate of test animals. These effects replicate results seen in workers breathing cadmium fumes. However, they have not been replicated in ingestion studies

or seen in men exposed only orally. Large doses of cadmium in drinking water have produced teratogenesis and other adverse effects in female rats.

Cadmium has been found to be nonmutagenic or only weakly mutagenic in a wide variety of in vivo and in vitro studies.

The toxicity of cadmium to aquatic life has been well documented. Like other heavy metals, its toxicity is influenced by water hardness, specifically calcium content (U.S. EPA, 1985b). As water hardness increases, cadmium toxicity decreases. The toxicity of cadmium is apparently caused by the soluble divalent form and not the insoluble precipitate (U.S. EPA, 1980g).

Cadmium has been observed to be both acutely and chronically toxic to aquatic life. In freshwater species, acute toxicity values for cadmium range from 1 to 75,000 $\mu\text{g/L}$ for fish and from 3.5 to 28,000 $\mu\text{g/L}$ for invertebrates (U.S. EPA, 1980g, 1985b). In a U.S. EPA study (1985b) where over 40 genera were tested for acute toxicity it was found trout and salmon were the most sensitive fish, and cladocerans such as *Daphnia* to be the most sensitive invertebrates.

The relationship between cadmium in sediments and toxicity in aquatic life has also been investigated. Schyutema and others (1984) found that cadmium adsorbed to sediment contributed negligibly to toxicity in *Daphnia magna*. They stated, however, that benthic organisms may be at higher risk since these organisms may ingest the contaminated sediments.

Chromium

The toxicology of chromium is complicated because of its complex chemistry and many oxidation states. Chromic (trivalent) chromium is the most common state, but chromate (hexavalent) chromium is the most toxic. Reviews used in this summary include documents prepared by Stokinger (1981), Carson and others (1986), Goyer (1986), ATSDR (1987c), NLM (1990), and U.S. EPA (1984f and 1984y).

Chromium is an essential trace mineral involved in a number of the enzyme systems used in carbohydrate metabolism. For example, chromium is necessary for insulin to produce its physiological effects. There have been reports of chromium deficiency in infants and elderly persons who suffer from malnutrition.

Chromium may enter the body through various routes, where it is absorbed, metabolized, or excreted. It is absorbed from the lungs and gastrointestinal tract, but not completely.

Chromate (hexavalent) chromium is better absorbed from the gut than chromic (trivalent) chromium, but only chromate is absorbed through the skin. It is likely that these differences in absorption account for most, if not all, of the observed differences in toxicity among the oxidation states. Animal studies have found high chromium levels in kidneys, lungs, and spleens. Chromate is reduced to chromic chromium inside the body. Excretion is primarily through the urine.

The studies reviewed identified both acute and chronic toxicity from exposure to chromium. The acute effects of chromium are rarely seen; specific toxic effects include gastrointestinal bleeding, fluid loss, and death from shock. A few cases of liver and kidney toxicity have been reported. Chronic toxicity is most commonly reported from industrial exposure to chromate or to mixed chromate and chromic forms of chromium. Exposure is primarily respiratory and dermal, with effects generally at the site of exposure. Typical symptoms include allergic contact dermatitis, skin ulcers, rhinitis, nasal membrane inflammation and ulceration, nasal septum perforation, tooth erosion and discoloration, pulmonary congestion, and pulmonary edema. Some cases also report liver and kidney lesions. Lung tumors are quite common in chromate-exposed workers; rates are highest among heavy cigarette smokers. There are some reports of cancers in other organs. There is no evidence of carcinogenicity for chromic chromium. A few studies have reported reproductive toxicity to animals, but the doses were quite large.

Chromium is fairly toxic to aquatic species (U.S. EPA, 1980a). Minimum toxic concentrations range from 0.03 mg/L to 64 mg/L of chromate for algae, 0.016 mg/L to 0.7 mg/L of chromate for *Daphnia magna*, 2.0 to 64.0 mg/L of chromic for aquatic insects, and 3 mg/L to 60.0 mg/L of chromic for benthic organisms. Increasing hardness decreases aquatic toxicity; one study found that hardness increased chromate's 96-hour LC50 for fathead minnows from 3 mg/L to 18 mg/L and for goldfish from 72 mg/L to 113 mg/L.

Excessive chromium is toxic to microorganisms (less than 1 mg/L for *Staphylococcus aureus*) and to plants (0.1 mg/L of chromate in the soil to the roots or 50 mg/L applied to the leaves).

Cobalt

Although cobalt is used for ceramics, pigments (cobalt blue), paint additives catalysts, and other purposes, most is used in alloys for high temperature use (turbine blades, high-speed tool steel) and magnets (Alnico and similar alloys). The toxic effects of cobalt have been reviewed by Carson and others (1986), NLM (1988), and Stokinger (1980).

Absorption of cobalt varies depending on its chemical form. Once absorbed, cobalt is widely distributed. The cobaltic trivalent form is usually rapidly converted to the stable cobaltous (divalent) form. Excretion is primarily into the urine, with small amounts extracted through the bile into the feces. Cobalt is an essential trace mineral, part of cyanocobalamin (Vitamin B₁₂), a cofactor in many enzyme systems.

The most commonly seen acute effect of cobalt is allergic dermatitis. If large doses are swallowed, cobalt produces a sensation of hotness with nausea, vomiting, and diarrhea. The usual effect of repeated inhalation is a pneumoconiosis. Other effects include hyperplasia in the thyroid and bone marrow, excessive blood cells, and loss of the sense of smell. The use of cobalt as a foam stabilizer led to epidemics of severe, often lethal, congestive heart failure caused by lesion of the muscle.

No data on aquatic toxicity were found.

Copper

Copper is well known as both an essential trace mineral nutrient and a toxicant. A number of reviews are available (Stokinger, 1981; U.S. EPA, 1981d, 1984k, 1985a; National Research Council, 1980a, 1980b; Goyer, 1986; Carson and others, 1986, NLM, 1990, ATSDR, 1989b).

Soluble copper salts are well absorbed by the human body. The copper is bound to serum albumin and a specific globulin, alpha-ceruloplasmin, and is distributed to depots in the liver (bound to specific proteins, including metallothionein) and bone marrow. Copper-containing enzymes are involved in hemoglobin synthesis, in maintaining connective tissue, and in other processes. Excretion is through the bile into the feces.

Acute toxic effects include gastrointestinal irritation, vomiting (including blood), low blood pressure, jaundice resulting from liver necrosis, and coma. Some cases of hemolytic anemia have been seen. Chronic toxicity is known as Wilson's disease, an inborn metabolic deficiency (Scheinberg, 1980). This causes accumulation of copper, with lesions in the liver, brain, and eye, plus hemolytic anemia. It is treated by removing the excessive copper from the body with a suitable chelating agent. In the absence of this disease, chronic copper toxicity is practically unknown because of the body's homeostatic mechanisms. There is no evidence that copper is a carcinogen.

In limited animal teratogenicity studies, copper has some effects at quite high doses.

The mechanism for copper toxicity in aquatic life is not well understood. The toxicity of copper to aquatic life has been shown to be related primarily to the activity of the divalent cupric ion, which is highly reactive, forms moderate to strong complexes, and precipitates with inorganic and organic constituents. U.S. EPA (1985a) documentation states that, in general, as hardness, alkalinity, and pH increase, the toxicity of copper decreases. However, the study also states that total organic carbon may be as important as hardness.

U.S. EPA (1985a) researches reviewed available data on copper toxicity in preparing water quality criteria. They found that acute toxicity with copper has been studied on various species of salmonids, minnows, bluegills, and invertebrates. The acute values ranged from 6.5 $\mu\text{g/L}$ for *Daphnia magna* in hard water to 10,200 $\mu\text{g/L}$ for the bluegill (*Lepomis gibbosus*) in hard water. The study also reported that adults were generally more resistant than juveniles within species.

Several authors studied the effects of water hardness on copper toxicity within a single species. For example, Lind and others (manuscript cited in U.S. EPA, 1985a) reported acute values for *Daphnia pulicaria* ranging from an LC50 of 9.3 $\mu\text{g/L}$ copper sulfate in soft water (45 mg/L as CaCO_3) to an LC50 of 27.3 $\mu\text{g/L}$ copper sulfate in hard water (245 mg/L as CaCO_3). Tarzwell and Henderson (1960, cited in EPA, 1985a) studied the acute toxicity of copper on fathead minnows (*Pimephales promelas*) and reported an LC50 at 50 $\mu\text{g/L}$ copper sulfate in soft water (20 mg/L as CaCO_3) and 1,400 $\mu\text{g/L}$ in hard water (400 mg/L as CaCO_3).

In its review, U.S. EPA (1985a) identified chronic toxicity test values for 10 fish species. These test values ranged from 3.9 $\mu\text{g/L}$ in an early life stage of brook trout to 60.4 $\mu\text{g/L}$ in early life stages of northern pike. For invertebrates, the levels ranged from 6.1 to 29.3 $\mu\text{g/L}$. Chapman and others (manuscript cited in U.S. EPA, 1985a) reported chronic values for *Daphnia magna* of 13.6 $\mu\text{g/L}$ in soft water (51 mg/L as CaCO_3) and 29.3 $\mu\text{g/L}$ in moderately hard water (104 mg/L as CaCO_3).

Other studies noted by U.S. EPA (1985a) include data on the toxicity of copper to aquatic plants. Toxic effects from copper have been shown to inhibit growth at concentrations ranging from 1 $\mu\text{g/L}$ to 8,000 $\mu\text{g/L}$.

Lead

Lead toxicity has been studied since the time of Hippocrates. This overview is based on authoritative reviews, including those by Stokinger (1981), U.S. EPA (1984a and 1988b), Carson and others (1986), Goyer (1986), ATSDR (1988a) and NLM (1990).

Normal adults will absorb about 10 percent of an oral dose of a lead compound, depending on the nature of the compound and on the individual. This absorption increases in children (up to 50 percent) and under some dietary conditions. About half the lead deposited in the alveoli is absorbed. Most (90 to 95 percent) of the absorbed lead is deposited in the mineral matrix of the skeleton; the rest is widely distributed. Lead is not metabolized, but its interactions with enzymes, especially sulfur-containing enzymes, produce its toxic effects. Excretion, mostly in the urine, is very slow; the half-life of lead in bones is about 20 years.

Large single doses of lead produce fatigue, sleep disturbances, and constipation, followed by colic, anemia, and neuritis. Chronic lead poisoning produces loss of appetite, metallic taste, constipation and obstipation, anemia, pallor, malaise, weakness, insomnia, headache, nervous irritability, muscle and joint pains, fine tremors, and colic. Other effects include certain muscular weaknesses ("wrist drop") and lead encephalopathy, as well as other effects seen in children. The minimal toxic effects seem to be learning deficits and growth retardation in children and hypertension in middle-aged men. Exposure to low doses of lead in childhood causes long-lasting effects, even in young adults (Needleman and others, 1990).

Lead is not known to be carcinogenic in humans; some animal studies have found kidney tumors at high but nonlethal doses. Therefore, the U.S. EPA has concluded that lead is a probable human carcinogen (U.S. EPA, 1990). Lead has severe reproductive toxicity. It can produce premature deliveries and spontaneous abortions in women and sterility in men. This sensitivity to lead toxicity extends from the fetal stage to the cessation of growth after puberty.

The major population at risk is young children in low income urban areas, who combine maximum sensitivity to lead's effects with maximum exposure (automobile exhaust, old paint, and other sources). The second most significant population at risk is pregnant women in those same areas. For these reasons, U.S. EPA documentation (1988c) recommends no lead at all in drinking water and proposes an enforceable limit of 5 $\mu\text{g/L}$.

Acute and chronic toxic effects of lead have been studied in a number of different aquatic organisms. As seen with other heavy metals, increased water hardness protects fish exposed to lead; however, little is understood of the actual mechanism. U.S. EPA (1980d and

1983b), in its review of acute toxicity tests, noted that lead was more toxic to *Daphnia magna*, rainbow trout, fathead minnow, and bluegill in soft water than in hard water. At a hardness of 50 mg/L, acute toxicities ranged from 148.9 µg/L for scuds to 236,600 µg/L for midges.

Results from chronic tests using freshwater aquatic organisms show the same relationship between lead toxicity and water hardness as seen in acute tests. Lead has been shown to be 11 times more toxic to *Daphnia magna* in soft water than in hard water. Lead has caused spinal deformities in rainbow trout, brook trout, northern pike, and walleye (U.S. EPA, 1980d). The lowest chronic value reported was for a cladoceran at 12.37 µg/L in soft water.

Acetone

Acetone is a widely used solvent for purposes ranging from the manufacture of smokeless powder to nail polish. It is also used as a chemical intermediate, a refrigerant, and for many other purposes. Its toxicity has been reviewed by Krasavage and others (1982), NLM (1990), and U.S. EPA (1984ee and 1990).

Acetone is readily absorbed by all routes and is widely distributed. It is a natural constituent of the body, produced during metabolism, and is normally found in blood and urine. Large doses of acetone are primarily exhaled unchanged, while smaller doses enter natural metabolism cholesterol, glycogen, and proteins. Acetone increases the action of some drug-metabolizing enzymes, causing numerous interactions. For instance, acetone and ethanol potentiate each other and acetone potentiates many chlorinated hydrocarbons.

Acetone is one of the least toxic solvents in industrial use. The main acute toxic effect is central nervous system depression, but irritation also occurs, especially in the eye. Reported doses have similar effects, leading to reports of skin defatting and inflammation. There are no reports of carcinogenicity or reproductive toxicity resulting from acetone exposure.

Acetone has very low toxicity to fish, with LC50 values ranging from 5,540 mg/L (rainbow trout) to 8,300 mg/L (bluegill sunfish). Amphibians and invertebrates are more sensitive, with LC50 values of 24 mg/L (clawed toad), 20 mg/L (Mexican axoloti), 10 mg/L (*Daphnia magna*) and 2,100 mg/L (brine shrimp).

Aldrin

Summary information concerning the toxicity of aldrin was obtained from the U.S. Environmental Protection Agency (EPA, 1985a; 1987a; 1992c) and the Agency for Toxic

Substances and Disease Registry (ATSDR, 1989a). Aldrin is rapidly converted to dieldrin after absorption. Aldrin and dieldrin can enter the body via inhalation, direct dermal contact, and ingestion routes. Based on laboratory studies with rodents, aldrin is classified as a probable human carcinogen via the ingestion route of exposure. In both humans and animals, the major noncarcinogenic acute and chronic effects associated with aldrin are:

- Central nervous system (CNS) disorders, including hyperexcitability and tremors followed by convulsions and possibly death;
- Liver disorders, including carcinoma, nonneoplastic histologic changes, increased liver-to-body weight ratios, and induction of liver microsomal enzymes;
- Kidney lesions at high doses;
- Reproductive effects, including decreased fertility, increased fetal death, and effects on gestation.

Aldrin has not been found to be teratogenic or mutagenic.

Carbon Disulfide

Carbon disulfide is an extremely flammable (flash point of 30° C), highly volatile (vapor pressure 297 mm Hg at 20° C) solvent used in the manufacture of rayon, cellophane, rubber, and other products. It also has been used as an intermediate in the production of carbon tetrachloride, as a pesticide (fumigant and soil treatment), and for other minor purposes. The toxicity of carbon disulfide has been reviewed by Andrews and Snyder (1986) and NLM (1990).

Carbon disulfide is absorbed through all routes, including the intact skin. It is widely distributed, but collects in fatty tissues. Although some carbon disulfide is exhaled, most is metabolized in the liver and possibly elsewhere and then excreted in the urine. This metabolism produces many products, most through two major pathways. In one, it reacts with amino acids to form dithiocarbamate, which reacts further. In the other pathway, carbon disulfide reacts with glutathione and then forms cyclic thioesters with carboxylic acid groups attached. Some of these metabolites may be involved in the toxic effects of carbon disulfide.

While carbon dioxide does cause some irritation and similar effects, such as defatting the skin, the major concern is the nervous system effects of repeated small doses seen occupationally. Carbon disulfide, especially in higher repeated doses, causes a characteristic encephalopathy, with symptoms including psychosis, agitated delirium, mental impairment, and behavioral effects similar to parkinsonism. It also causes peripheral neuropathy, retinopathy, and hearing loss. There is evidence that carbon disulfide also increases the incidence of coronary heart disease and

consequently heart attacks. Women seem somewhat more susceptible, probably because their higher body fat content increases the amount of carbon disulfide the body holds.

No useful studies on carcinogenicity or on environmental toxicity were found. However, carbon disulfide is well known to have adverse reproductive effects. In female workers, these are nonspecific effects that include menstrual problems and spontaneous abortions. Similar nonspecific effects, including fetal malformations and toxicity, were seen in the animal study that is the basis for the reference dose (IRIS, 1990).

Chlordane

Chlordane is moderately toxic through all routes of exposure and may pose significant health risks to the liver of chronically exposed humans. Based on studies in which liver tumors were induced in various strains of mice and rats, chlordane is classified as a probable human carcinogen via the ingestion and inhalation routes of exposure (EPA, 1992c). Acute exposure to chlordane produces such CNS effects as hyperexcitability, convulsions, depression, and death. Chronic exposure may also produce hematologic and neurotoxic effects. Chlordane also produces adverse reproductive effects in mice.

Chlorobenzene

Chlorobenzene is used as a chemical intermediate and as a solvent. Its toxicity has been reviewed in Deichmann (1981), U.S. EPA (1984d), ATSDR (1989h) and NLM (1990).

Chlorobenzene is well absorbed after inhalation and ingestion; no data are available on transdermal absorption. It is oxidized in the liver to chlorophenol, which is conjugated, further oxidized, or both, and excreted in the urine. In addition, substantial amounts are exhaled unchanged. There are some known interactions with other chemicals involved with the same metabolic pathways, but the toxicological significance of these biochemical effects is unknown.

Single doses of chlorobenzene to animals cause salivation and lacrimation, excitation followed by drowsiness, respiratory difficulty, and paralysis. Death, which may be delayed a few days after exposure, is caused by respiratory paralysis, but there are also lesions in the liver, kidney, lungs, stomach, and brain. Humans occupationally exposed have many effects, primarily on the nervous system, that include headaches, dizziness, sleepiness, upset stomach, paresthesias, contractions of some finger and leg muscles, and liver lesions. Some animal studies report effects on the blood.

The one reported carcinogenesis study found some, though not clear, evidence of carcinogenicity in male rats and no evidence in female rats and in male and female mice. One animal study found no reproductive toxicity at doses that caused liver toxicity.

The few environmental toxicity studies report acute LC50 values of 19 to 39 mg/L in various fish. One comparative study found chlorobenzene was less toxic to the livers of trout than to the livers of rats. This hepatotoxicity seems to be the most sensitive indicator of chlorobenzene toxicity and is the basis of the reference dose (IRIS, 1990).

Chloroform

Chloroform is now used primarily as a solvent and chemical intermediate. It was formerly used as a pharmaceutical (especially as a general anesthetic) and grain fumigant. It is found in drinking water as a byproduct of chlorination. The toxicity of chloroform has been reviewed by ATSDR (1987b), NLM (1990), Torkelson and Rowe (1981), and U.S. EPA (1984a and 1985c).

Chloroform is well absorbed by all routes: oral, inhalation, and dermal. Once absorbed, it is widely distributed, with high concentrations in fat tissue and in organs containing high levels of fat-like compounds, especially the brain. Some chloroform is exhaled unchanged, but the rest is oxidized in the liver and other organs through phosgene to carbon dioxide, which is then exhaled. The ratio between metabolized and unmetabolized excretion is difficult to predict, and varies with the species, sex, amount of body fat, dose, and other factors.

The main adverse effect noted after single doses of chloroform was central nervous system depression, which could be readily intensified to the level of anesthesia. Chloroform was used as a general anesthetic for decades, until studies found that single doses were capable of causing serious and even fatal liver and kidney damage in some patients. It also occasionally caused cardiac arrest. Acute exposure via inhalation can result in depression of the central nervous system affecting regulation of body temperature and respiration, as well as cardiovascular and vasomotor functions. The major adverse effects of repeated doses of chloroform are on the liver and kidney. There is great variation between species, strains, and even between individuals, in their susceptibility to these effects. For instance, kidney lesions are very rare in humans, but common in male mice of certain strains. Only two studies of chronic exposure via inhalation were identified. These suggest that such exposure may result in tiredness, dull-wittedness, depression, gastrointestinal distress, and frequent scalding urination.

Chloroform has caused liver and kidney tumors in rats and mice in a number of studies. Therefore, chloroform is considered a probable human carcinogen. Numerous studies of humans have found evidence of increased cancer rates in persons drinking chlorinated water, but it is not certain how much of this effect can be ascribed to the chloroform and how much to the other chlorinated chemicals in the water. In several animal reproductive toxicity studies, chloroform affected the young only at doses that had significant adverse effects on the mothers.

A few aquatic toxicity studies of chloroform have been reported. Acute LC50s for fish have ranged from 44,000 $\mu\text{g/L}$ (rainbow trout; *Salmo gairdneri*) to 100,000 $\mu\text{g/L}$ (bluegill; *Lepomis macrochirus*). A commonly used invertebrate, *Daphia magna*, was more sensitive, with an LC50 of 29,000 $\mu\text{g/L}$. One chronic study with rainbow trout found LC50s of 2,030 $\mu\text{g/L}$ in soft water and 1,240 $\mu\text{g/L}$ in hard water.

DDT, DDD, and DDE

The environmental behaviors of these three compounds are discussed together since DDD and DDE are degradation products of DDT. While DDD is manufactured as a commercial product, DDE is formed exclusively as a degradation product. Although all three compounds have several isomers, the PP' isomer is the major component.

The K_{ow} and K_{oc} values for all three compounds are very high, indicating the importance of sorption mechanisms. All of these compounds may be classified as immobile in soil-water environments (McCall and others, 1980). In surface waters, DDT, DDD, and DDE are expected to sorb onto suspended particulates and sediments. In soil environments, these compounds are expected to sorb strongly onto surface soil and movement to the subsoil through the soil column is extremely unlikely. Sanborn and others (1977) discussed several studies designed to determine the residue levels in surface soils following DDT application. Most of these studies reported of residual DDT in soils many years after application.

DDT is expected to volatilize from aquatic systems more rapidly than DDD or DDE based on the Henry's Law constant values. However, experimental data do not support this hypothesis. Callahan and others (1979) discussed a study by Singmaster, which reported that if volatilization potential for DDE is set at 10, the DDT and DDD volatilization potentials are 3 and 1, respectively. High sorption potential for these compounds indicates that volatilization from soils probably has minimal effect on eliminating DDT, DDD, and DDE from soils. However, loss from volatilization may continue over a long period of time. Spencer (1975) (as reported in Sanborn and others, 1977) concluded that DDT will continue to enter the atmosphere long after its use has been suspended.

Bioconcentration of DDT in fish, birds, and animals has been well documented. Fish BCF values for DDT and DDE listed in Table J-1 are 54,000 and 51,000, respectively. Veith and others (1979) reported bioconcentration factors of 29,900 and 51,000 in fathead minnows for DDT and DDE, respectively. Callahan and others (1979) reported a study in which bioconcentration factors of between 933,967, and 6,500 were found for DDD in snail, mosquito larvae, and fish. These high BCF values indicate that even though DDT, DDD, and DDE are only sparingly soluble in water, aquatic organisms can still accumulate these compounds to extremely high levels. Sanborn and others (1977) discussed several studies that showed DDT and DDE accumulation in terrestrial animals.

Several studies have evaluated the biodegradation and biotransformation of DDT and its metabolites. Newsom (1985) stated that microbial degradation of DDT occurs more readily under anaerobic conditions than aerobic conditions and that DDT can be biotransformed to DDD and DDE by a wide range of microorganisms in both soil and aquatic environments. Sanborn and others (1977) discussed a study of DDT conversion in Everglades muck soil. In that study, DDT conversion was slow, with 10.1 and 2 percent converting to DDD and DDE, respectively. Another study (Callahan and others, 1979) stated that although no data are available on the biotransformation rates of DDD and DDT, biotransformation is very important in determining the ultimate fate of these compounds. DDD probably metabolizes more easily than DDT or DDE. Studies indicate that DDE is probably a stable end product of DDT and that biotransformation of DDE is not an important fate process.

Callahan and others (1979) reported that photolysis and oxidation of DDT and DDD from aquatic systems are very slow processes. Photolytic half-lives of DDE were reported to range from 1 to 6 days from aquatic environments. DDE oxidation also could be an important fate process. While hydrolysis of DDD and DDE is very slow, DDT hydrolysis is an important fate process.

1,1-Dichloroethane

1,1-Dichloroethane, known commercially as ethylidene chloride and ethylidene dichloride, is a flammable compound with limited use as a solvent and chemical intermediate. This summary is based on reviews of the limited available data by Torkelson and Rowe (1981), U.S. EPA (1984), and NLM (1990).

1,1-Dichloroethane is apparently absorbed by inhalation, ingestion, and through the skin, and is excreted in exhaled air. No metabolic data are available.

Most of the available data focused on the effects from acute exposure. The major effects of acute exposure to 1,1-dichloroethane are local irritation and central nervous system depression. The chemical once had limited use as an anesthetic. Very high doses (near lethal) produce some liver and kidney lesions. In the few reported studies, repeated doses have not produced specific toxic effects, but did result in decreased weight gain and an increased death rate. The one available reproductive toxicity study found limited, nonspecific adverse effects at quite high doses.

No information was found on the aquatic toxicity of 1,1-dichloroethane. Its high volatility greatly decreases its residence time in water, and therefore decreases the possibility of any adverse effects on aquatic biota.

1,2-Dichloroethane

1,2-Dichloroethane, known commercially as ethylene dichloride, is primarily used as a chemical intermediate in the production of vinyl chloride and other chemicals. Some is used as a solvent or for other purposes. The toxicity of 1,2-dichloroethane has been reviewed by NLM (1990), Torkelson and Rowe (1981), and U.S. EPA (1984q).

1,2-Dichloroethane is absorbed by all routes: oral, inhalation, and dermal contact. Distribution is not well reported. 1,2-Dichloroethane is metabolized in the liver through a number of pathways, leading to a variety of products. Unmetabolized 1,2-dichloroethane and carbon dioxide are exhaled, while other metabolites are excreted in the urine, with only traces of the chemicals excreted in the feces or incorporated into the body. These processes have not been studied in humans, and the relative importance of various pathways varies considerably between species. Therefore, extrapolating from laboratory animals to humans is more uncertain than usual.

The main effects of acute doses are irritation at the site of contact and central nervous system depression. Large doses also produce lesions in the liver, kidney, and adrenals. Repeated doses affect the same organs, causing similar lesions plus characteristic scarring. Carcinogenesis studies in rats and mice found that 1,2-dichloroethane produced a variety of tumors, so it is considered a probable human carcinogen. The few reproductive studies reported no adverse effects.

In limited aquatic toxicity studies, 1,2-dichloroethane showed low toxicity, with acute LC50s in invertebrates and fish exceeding 100,000 µg/L.

1,1,-Dichloroethene

1,1-Dichloroethene, commonly known as vinylidene chloride, is used as a chemical intermediate, primarily for polymers such as modacrylic and saran fibers. The toxicity of 1,1-dichloroethene has been reviewed by NLM (1990), Torkelson and Rowe (1981), and U.S. EPA (1980h and 1984r).

1,1-Dichloroethene is absorbed by all routes: oral, inhalation, and dermal contact. It is extensively metabolized in the liver, primarily by oxidation and conjugation. Metabolites are excreted in the urine, while some unchanged chemical is exhaled, especially after large doses that saturate the enzymatic pathways. There are a number of known interactions with other compounds because of the effects of 1,1-dichloroethene and the other compound on metabolic enzymes. Species of test animals that metabolize 1,1-dichloroethane more easily (such as mice) are more sensitive to its toxic effects.

The main effect of a single dose of 1,1-dichloroethene is a fully reversible central nervous system depression. The liquid is quite irritating to the skin, respiratory tract, and eyes; however, much of the cornea injury may be caused by the phenolic polymerization inhibitor in the commercial product. Repeated doses produce a variety of liver and kidney lesions. There have been 18 animal carcinogenicity studies, but most have been inadequate, and many found no increases in tumors. From these data, 1,1-dichloroethene is considered only as a possible human carcinogen. Reproductive toxicity has been seen only at doses that produced maternal toxicity. Exposure to high concentrations via inhalation sensitizes the myocardium to arrhythmias by epinephrine injection.

In limited acute aquatic toxicity studies, 1,1-dichloroethene was relatively nontoxic to fish, with LC50 values ranging from 74 mg/L (bluegill) to 250 mg/L (sheepshead minnow, inland silverside). Lower species are even less sensitive, with LC50 values above 700 or 800 mg/L for mysid shrimp and several algae.

1,2-Dichloroethene

1,2-Dichloroethene, and its cis- and trans-isomers, are used as chemical intermediates. They have generally been replaced as solvents (for rubber, for extracting caffeine from coffee, for various fats and oils) by nonflammable solvents. A typical commercial mixture is 60 percent cis-isomer and 40 percent trans-isomer. The limited toxicity data for 1,2-dichloroethene have

been reviewed by ATSDR (1989c), NLM (1990), Torkelson and Rowe (1981) and U.S. EPA (1984m and 1984n).

There are no solid data on the absorption, distribution, and excretion of 1,2-dichloroethene. However, toxic effects have been seen after ingestion and inhalation. 1,2-Dichloroethylene is metabolized to dichloroacetaldehyde, dichloroethanol, and chloroacetic acid.

The major effect of acute doses of 1,2-dichloroethene is central nervous system depression. There is also some irritation at the site of contact, including the eyes. Some studies have reported that the cis-isomer is twice as potent as the trans-isomer, but other studies have found no such differences. Repeated inhalation causes lesions in the lungs (apparently from contact irritation), liver, and kidney. One study also reported an adverse effect (decrease in the number of antibody-forming cells) on the immune system.

No carcinogenicity, reproductive toxicity, or aquatic toxicity studies were reported.

Ethylbenzene

Ethylbenzene is used as a chemical intermediate, especially for styrene, and as a solvent. It is found in gasoline and similar petroleum distillates. The limited data on ethylbenzene are reviewed in Sandmeyer (1981), U.S. EPA (1984s), and NLM (1990). Ethylbenzene seems to be practically indistinguishable from xylene in its biological effects.

Ethylbenzene is well absorbed from the lung and gastrointestinal tract, but poorly absorbed through the skin. Small amounts are exhaled unchanged, but most is metabolized in the liver, primarily by oxidation of the side-chain, and excreted in the urine. The mix of metabolites varies considerably among species; in humans, mandelic acid (2-phenyl-2-hydroxyacetic acid), and phenylglyoxylic acid (2-phenyl-2-ketoacetic acid) are the major urinary metabolites.

Acute doses of ethylbenzene are highly irritating, especially to sensitive tissue such as the eyes and the lining of the lung alveoli. Sufficiently large doses produce central nervous system depression. Repeated doses have been reported to cause a number of lung, nervous system, bone marrow, and hepatic lesions in workers. Inflammation of the respiratory tract from repeated irritation of inhaled ethylbenzene seems to be the most frequent complaint. Mild, nonspecific adverse effects, such as retarded skeletal development, are observed in the few available animal reproductive studies. No chronic or carcinogenicity studies are available.

Ethylbenzene is moderately toxic to aquatic species. LC50 values range from 10,000 µg/L for grass shrimp (*Palemonetes pugio*) larvae to 275,000 µg/L for sheepshead minnow (*Cyprinodon variegatus*). No chronic studies are available.

Gasoline

Gasoline is an extremely complex, variable mixture of hydrocarbons (Sandmeyer, 1981; Hoffmann, 1983; Andrews and Snyder, 1986). It typically includes alkanes (straight chain and branched), alkenes, and aromatics boiling between 32° and 210° C. Many gasolines contain other additives, such as tetraethyl lead, methanol, or methyl t-butyl ether. Except for the extremely dangerous alkyllead compounds being phased out, these additives are usually toxicologically unimportant. Gasolines are made to meet performance specifications; the usual parameters are volatility (within specified limits, which vary with season and ground elevation in the area of intended use), sulfur content (as low as practical), and octane number (which depends on the detailed chemical composition).

Gasoline is predominantly aliphatic hydrocarbons, but some crude oils have relatively high aromatic hydrocarbon content, which is passed to the products. In addition, producers have been increasing the aromatic content of gasolines to compensate for the decrease in alkylleads, since the aromatics have antiknock effects.

The few data on gasoline toxicity reflect large doses, typically the results of a person drinking some gasoline stored in a soft drink bottle. The observed effects are those expected from the components: irritation and central nervous system depression. Repeated doses have few effects other than defatting of the skin from contact with the liquid and lead toxicity from deliberately inhaling leaded gasolines. Toxic effects have been reported in ordinary gasoline use only in extreme conditions, such as gasoline pump workers in the hot environment of Lucknow, India.

gamma-Hexachlorocyclohexane (Lindane)

The gamma (lindane) isomer of hexachlorocyclohexane has been shown to cause liver tumors in laboratory animals and is classified as a probable human carcinogen via the oral route. Studies have shown the development of benign hepatomas, hepatocellular carcinomas, or liver tumors in mice fed lindane (EPA, 1992c). Exposure to lindane has also been associated with embryo mortality in rodents, and the development of aplastic anemia in humans (EPA, 1985a).

Phenol

Phenol is primarily used as a chemical intermediate. It is the original antiseptic under its old name of carbolic acid, but has been generally discarded in favor of less toxic substitutes. The toxicity of phenol has been reviewed in Deichmann and Keplinger (1981), NLM (1990), and U.S. EPA (1984dd).

Phenol is well absorbed by all routes, including through the skin. It is oxidized in the liver. The metabolites and unchanged phenol are reacted with sulfate, glucuronate, or similar chemical-specific molecules and the products are excreted in the urine, along with some unconjugated species. The mixture of compounds excreted varies with the species and the dose involved.

Acute doses of phenol have two major effects: irritation at the site of contact and central nervous system stimulation. Phenol has very low thresholds for taste and odor. The irritation can produce severe damage, especially to the gastrointestinal tract, including bloody vomiting and diarrhea, but the usual causes of death are the nervous system effects. In humans this is usually seen as a sudden collapse (muscular weakness and unconsciousness) followed by variations in pulse, respiration, and body temperature leading to death from respiratory failure. Death may occur within 10 minutes of being splashed. Some animals have tremors or convulsion, and such effects are occasionally seen, but never marked, in humans.

Repeated exposure to phenol causes symptoms like acute doses. In addition, there may be pigmented spots, especially on the sclera (covering of eyeball) and above the tendons of the knuckles of the hand. Finally, there is extensive damage to the liver and kidneys, which has resulted in death in severe cases. There are no useful studies on carcinogenesis and reproductive toxicity.

Because of phenol's use as a standard disinfectant, there are considerable data on its acute toxicity to aquatic species. For fish, LC50s vary from 4 to 50 mg/L, with significant variations between different studies of the same species. Some of that variation may be accounted for by the pH of the water which affects the degree of ionization. The hardness of the water does not affect phenol's toxicity. Nonvertebrate species, such as *Daphnia magna*, algae, and bacteria, are somewhat more resistant to phenol toxicity.

Phthalates

Phthalate esters are widely used in polymer products as plasticizers. Some very flexible products, such as household wrap (of polyvinyl chloride) may be half phthalate esters by weight. The best studied example of the class is bis(2-ethylhexyl)phthalate, also called di-iso-octyl phthalate. This review, which also includes di-n-butyl phthalate, n-butyl benzyl phthalate, and di-n-octyl phthalate, is based on studies by U.S. EPA (1980m), Sandmeyer and Kirun (1981), ATSDR (1987f), and NLM (1990).

Phthalate esters are slowly absorbed from the gastrointestinal tract. There is no evidence of significant absorption through the lung or skin. Once absorbed, they are rapidly desaponified to phthalic acid (which is excreted in the urine) and alcohol (which is generally metabolized to carbon dioxide).

The combination of poor absorption and rapid metabolism means phthalate esters have little acute toxicity, except for a few rare esters with toxic alcohols. The most common effects are local irritation (eye inflammation, eczema, nausea, abdominal cramps, and similar effects) and some central nervous system depression. Repeated doses of phthalate esters to animals cause lesions in the liver and testes. These chemicals have adverse, but nonspecific, effects on fetuses. Bis(2-ethylhexyl)phthalate causes a different sort of lesion in rodent livers than others (such as its isomer, di-n-octyl phthalate). This lesion then develops into hepatic cancers, so bis(2-ethylhexyl)phthalate is considered a probable human carcinogen.

Bis(2-ethylhexyl)phthalate has very low aquatic toxicity; most studies show no effect at the highest concentrations of 100,000 to 800,000 $\mu\text{g/L}$. One exception is *Daphnia magna*, with an LC50 of 1,100 $\mu\text{g/L}$. Dibutyl phthalate is more toxic, with LC50s around 800 $\mu\text{g/L}$ for the scud (*Gammarus fasciatus*) and midge (*Chironomus plumosus*).

Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are persistent chemicals. Because of their frequent appearance as environmental contaminants, PCBs have been frequently studied and reviewed (Deichmann, 1981; U.S. EPA, 1980b and 1984e; ATSDR, 1987f; NLM, 1990).

PCBs are well absorbed from the gut. Dermal and respiratory absorption also occur. PCBs initially concentrate in the liver, blood, and muscle, but soon migrate to the fat tissue where they have a very long half-life. PCBs are metabolized to biphenyls, biphenyldiols, and dihydrodihydroxybiphenyls through arene oxide intermediates. Excretion is through the urine

and feces. Although there are species variations, the more highly chlorinated compounds are excreted more in the feces and are less readily metabolized than their less chlorinated relatives.

There are few dose data for humans; at most there are high and low exposures plus a control (no exposure) group. The animal studies show a considerable variation in equi-effective doses between species of both animals and PCBs. However, in comparable studies, the more chlorinated mixtures are more toxic than the less chlorinated ones. This trend is true for most studies, from LD50 to carcinogenicity.

In humans, the primary acute toxic effect of PCBs is chloracne. No distinctive acute effects have been reported in animals. Repeated dose toxicity in humans is known as "Yusho disease" after the residents of Yusho, Japan, who ate rice bran oil contaminated with PCBs for several months. After a latent period of several months, the victims developed chloracne, pigmentation of skin areas, visual disturbances, gastrointestinal distress, jaundice, and lethargy. Infants from exposed mothers had low birth weight and pigment blotches. Some observers have ascribed some or even most of this toxicity to the chemically related polychlorinated dibenzofurans (PCDFs) in the mixture with the PCBs. These PCDFs are decomposition products of PCBs, formed in large quantities by fires involving PCBs. Industrial exposure, generally dermal, produces chloracne and, in severe cases, hepatotoxicity.

PCBs are carcinogenic in some animal studies. There is some indication from occupational and Yusho exposures that PCBs are carcinogenic in humans, but this evidence is not definitive because of other simultaneous exposures.

PCBs have reproductive toxicity, based on results of the few animal studies, the Yusho incident and more recently a similar incident in Taiwan (Rogan and others, 1988) and a study of mothers eating PCB-contaminated fish. Effects were similar to adult toxicity; nonspecific effects included low birth weight and spontaneous abortions or still births and skin lesions. In the few studies found, PCBs have little or no mutagenicity.

U.S. EPA (1980b) reviewed the available aquatic toxicity data in establishing the ambient water quality criteria for PCBs. As described earlier, PCBs have low water solubility, and this has governed the exposure levels in toxicity tests. Also, PCBs are mixtures of several isomers with ranging degrees of chlorination; these mixtures are known by the trade name Aroclor. Most toxicity testing of PCBs involved various Aroclors.

The acute toxicity testing of PCBs has involved invertebrates and vertebrates, and freshwater and marine organisms. The acute values for freshwater invertebrates ranged from 10

µg/L to 400 µg/L; the values for newly hatched freshwater fish ranged from 2.0 µg/L to 7.7 µg/L, with values for mature fish much higher; the values for marine invertebrates ranged from 10.2 µg/L to 60 µg/L (U.S. EPA 1980b; NLM, 1990).

The chronic toxicity of PCBs was determined by a number of studies (U.S. EPA, 1980b). The chronic values for freshwater invertebrates ranged from 0.8 µg/L to 4.9 µg/L; for fish the range was 0.3 µg/L to 9.0 µg/L. Most of the variations reported were attributed to the various Aroclors tested rather than to the species tested. No data were available on chronic toxicity to marine organisms.

Polycyclic Aromatic Hydrocarbons

Polycyclic (or polynuclear) aromatic hydrocarbons (PAHs) are chemicals containing three or more fused, aromatic hydrocarbon rings; some authors included two ring systems (naphthalene and derivatives), some heterocyclic systems (such as dibenzofuran and dibenzodioxin), or both. PAHs are generally found as a highly complex mixture in the products of incomplete combustion (coal soot, cigarette smoke, motor vehicle exhaust, and so on). Seventeen PAHs are included in U.S. EPA's hazardous substances list, but few are well studied. The most recent general evaluation (National Institute for Environmental Health Sciences, 1989) concludes that the following PAHs are probably carcinogenic:

- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(j)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Dibenz(a,h)acridine
- Dibenz(a,j)acridine
- Dibenzo(a,h)anthracene
- 7H-Dibenzo(c,g)carbazole
- Dibenzo(a,e)pyrene
- Dibenzo(a,h)pyrene
- Dibenzo(a,i)pyrene
- Dibenzo(a,j)pyrene
- Indeno(1,2,3-cd)pyrene
- 5-Methylchrysene

Another study (ATSDR, 1987j) has added chrysene to the list. The total concentration of these chemicals was used in the calculations of this report. This section focuses on the best studied PAH, benzo(a)pyrene (BAP); most data apply to all PAHs, especially to all carcinogenic PAHs. Reviews included studies by Sandmeyer (1981), U.S. EPA (1982e, 1982f, 1984z, and 1989), ATSDR (1987g, 1987h, 1987i, 1987j, 1987k, 1989e, and 1989g), Williams and Weisburger (1986), and NLM (1990).

Absorption of BAP and other PAHs has been demonstrated indirectly, because toxic effects have been seen after oral and inhalation exposure. PAHs are oxidized in the liver by an enzyme, aryl hydrocarbon hydroxylase (AHH), to the epoxide, which hydrolyzes to the hydroxy or dihydroxy derivative. The metabolites are the active forms of the chemicals; variations in the formation (amount, rate, products) of these metabolites account for the different effects of the various PAHs. PAHs also cause the synthesis of greater quantities of AHH and other drug-metabolizing enzymes; therefore, simultaneous exposure to PAHs and other toxicants increases or decreases the toxicity of the other toxicants. A few nonmetabolic interactions also exist. For example, BAP increases the cardiac sensitization effects of trichloroethene. PAHs are excreted as a large variety of oxidized metabolites and conjugated metabolites, mostly through the bile into the feces.

Single, acute oral and dermal doses of PAHs are practically nontoxic to animals; no human data are available. Repeated doses of straight-chain PAHs (naphthalene, anthracene, pentacene, and others) also have little effect; most data are animal-related. These PAHs in large doses produce weight loss, possibly blood effects (even aplastic anemia), and some liver and kidney lesions, but do not seem to be carcinogenic. Other PAHs, such as BAP, are carcinogenic after repeated doses through the oral, inhalation, and dermal routes. Tumors develop at the entry site (stomach, lung, skin) and in the liver, breast, and occasionally at other sites. Other effects are like straight-chain PAHs. Dibenzo(a,h)anthracene was the first pure chemical shown to be carcinogenic to animals in experiments during the 1920s, while coal soot, now known to be primarily PAHs, was recognized as the cause of scrotal cancers in chimney sweeps in 1775. Several of the PAHs, including BAP, are routinely used in the laboratory to induce tumors in rodents; a few laboratory workers have developed similar tumors from accidental exposures to these chemicals. Except for those laboratory accidents, all human data are for exposure to complex mixtures where it is impossible to determine the effects of specific chemicals. However, PAHs are believed to be the principal carcinogenic component of tobacco smoke and similar mixtures. In mutagenic studies, PAHs are usually highly mutagenic if activated by metabolic reactions. In fact, BAP is commonly used as a positive control, to check whether a test system can demonstrate mutagenicity. The carcinogenic PAHs are also immunotoxic; the more potent carcinogens are also more potent immunosuppressants.

PAHs show little, if any, reproductive toxicity in the few available studies, except in parenteral studies of BAP in rodents. Most adverse effects were nonspecific, such as decreased birth weight and reproductive performance, and were at relatively high doses. The potency of BAP as a reproductive toxicant was markedly affected by inborn differences in metabolism among various strains of mice, emphasizing the importance of metabolism to the toxicity of these compounds.

In all human studies, the only dose data available are semi-quantitative estimates for PAH mixtures. For instance, studies of cigarette smoking usually measure doses in "pack-years," smoking one pack a day for a year. Animal experimental studies show considerable dose variation among the various PAHs.

Only limited studies are available on the toxicity of PAHs to aquatic organisms. U.S. EPA (1982e) reported a study that found 87 percent mortality in bluegill after 6 months of exposure at 1.0 mg/L to benzo(a) anthracene. The study also reported increased tumors in benthic fish associated with sediments containing high PAH levels. There are a few reported studies of acute toxicity (NLM, 1990). The range of LC50s of acenaphthene to various freshwater fish was from 600 $\mu\text{g/L}$ (brown trout) to 1,700 $\mu\text{g/L}$ (fathead minnow). Fluoranthene was more toxic to mysid shrimp (LC50 of 40 $\mu\text{g/L}$ and acute/chronic ratio of 2.5) but less toxic to fish (LC50 of 4,000 $\mu\text{g/L}$ to bluegill), with very little toxicity to algae (LC50 of 45,000 and 54,400 $\mu\text{g/L}$).

1,1,2,2-Tetrachloroethane

1,1,2,2-tetrachloroethane is mutagenic and classified as a possible human carcinogen. Chronic exposure causes increase mortality, especially in female rodents. A highly significant dose-related increase in the incidence of liver carcinomas was observed in both male and female mice (EPA, 1992c).

Tetrachloroethene

Tetrachloroethene is a commonly used industrial solvent. It has been reviewed by U.S. EPA (1980i, 1982b, 1983d, 1984t, and 1986c), Torkelson and Rowe (1981), NLM (1990) and ATSDR (1987a).

Tetrachloroethene is well absorbed from the lungs, but less so from the gastrointestinal tract and through the skin. It is widely distributed throughout the body, with deposits in fat; because of its lipophilicity, these deposits are greater for tetrachloroethene than for the related

contaminants of concern. Most tetrachloroethene is exhaled unchanged, but some is metabolized in the liver and excreted in the urine. The amount of this metabolism varies greatly among species; the metabolites, especially the highly reactive epoxide, are believed to be responsible for the compound's carcinogenicity and some other toxic effects.

The major acute toxic effect of tetrachloroethene is central nervous system depression. Other effects include irritation (especially of mucous membranes) and lesions in the liver and kidneys. Tetrachloroethene is less potent than related compounds for all these effects; for instance, it cannot produce surgical anesthesia. Tetrachloroethene's former usage in the treatment of hookworms suggests that it is not highly toxic when given orally to humans.

Repeated doses produce considerable hepatotoxicity and often nephrotoxicity. Rarer effects include pulmonary edema (after inhalation) and dermatitis resulting from skin defatting (after dermal contact). There is no evidence of teratogenicity in the few available studies. Tetrachloroethene is carcinogenic in animal studies. Limited human studies have found no carcinogenicity, which has been attributed to the proportionately lower metabolism in humans as compared to rodents.

There has been little attention paid to the environmental toxicity of tetrachloroethene, primarily because of its low aqueous persistence resulting from its high volatility. In reported toxicity studies, the rainbow trout (*Salmo gairdneri*) is the most sensitive species, with a 48-hour LC50 of 4,200 µg/L. Other animal species, *Daphnia magna* and various fish, had LC50s ranging from 12,900 to 21,400 µg/L. The green alga *Selenastrum capricornutum* was not affected at much higher concentrations (up to 816,000 µg/L), although a study in an experimental pond found that four of six species of phytoplankton were eliminated after an initial concentration of only 440 µg/L. The only chronic study used the fathead minnow *Pimephales promelas* and found effects at 840 µg/L of chronic dosing comparable to the effects at 13,460 µg/L of acute dosing. One acute study with bluegill, *Lepomis macrochirus*, and *Daphnia magna* found tetrachloroethene to be more toxic by factors of 3.5 to 5.7 than 1,1-dichloroethene and trichloroethene.

Toluene

Toluene (methylbenzene, phenylmethane, toluol) is the simplest alkylbenzene. Since benzene was determined to be a human carcinogen, toluene has been increasingly used as a less toxic substitute. Toluene's toxicity is reviewed in studies by Sandmeyer (1981), U.S. EPA (1981a, 1982a, and 1984b), ATSDR (1989a), and NLM (1990).

Toluene is well absorbed orally and by inhalation. It is widely distributed with high concentrations in the liver where it is metabolized, and the kidney where it is excreted. Some is exhaled unchanged, but most is oxidized and rapidly excreted in the urine.

Acute exposures cause irritation (including chemical pneumonia if liquid is aspirated into the lung) and central nervous system depression, even at human doses as low as 100 to 200 ppm in air. Extremely high concentrations (near lethal) have been reported to reversibly decrease erythrocyte levels and cause liver and renal toxicity. Chronic dosing affects the skin (dissolving the secreted fat), central nervous system, liver, and kidney, although no quantitative human data are available. There is no evidence of carcinogenicity or of reproductive toxicity in the available studies. Toluene was not found to be mutagenic in the few reported studies.

Acute toxic effects of toluene in aquatic organisms include changes in gill permeability and internal CO₂ poisoning. Most LC50 values for fish and invertebrates are between 10,000 µg/L and 100,000 µg/L. U.S. EPA (1981a) documentation reports that the most sensitive species tested is the striped bass (LC50 = 6,300 µg/L), and the most resistant is the mosquito fish (LC50=1,000,000 µg/L).

No data were available on chronic toxicity and sublethal effects in aquatic organisms.

1,1,1-Trichloroethane

1,1,1-Trichloroethane, known commercially as methyl chloroform, is a widely used nonflammable solvent. It is probably the least toxic of the chlorinated solvents. It has been reviewed by Torkelson and Rowe (1981), U.S. EPA (1982d and 1984u), and NLM (1990).

1,1,1-Trichloroethane may enter the body through various routes where it may be excreted or metabolized. It is completely absorbed after ingestion, well absorbed after inhalation, and slowly absorbed through the skin. It is concentrated in fat and in organs with high levels of fat, such as the brain. Most is exhaled unchanged, but small amounts are metabolized to trichloroethanol and other metabolites, and then excreted in the urine.

The information reviewed identified both acute and chronic toxicity associated with exposure to 1,1,1-trichloroethane. The main effects of acute toxicity are central nervous system depression and mild irritation. However, when 1,1,1-trichloroethane was studied as a general anesthetic, it was found to produce cardiac sensitization and sometimes lethal arrhythmias. Chronic toxicity, which is rarely reported in humans, usually involves kidney and liver lesions. Animal studies have found similar effects.

The few available studies have found neither carcinogenic effects nor reproductive toxicity.

Limited information was found in the aquatic toxicity of 1,1,1-trichloroethane. Hermens and others (1984) noted an IC50 (immobilization) for *Daphnia magna*, based on a quantitative structure activity relationship of 37.5 mg/L. This indicates low toxicity to this species.

1,1,2-Trichloroethane

1,1,2-Trichloroethane, known commercially as vinyl trichloride, has a few minor uses as a chemical intermediate and as a solvent. Its relatively high toxicity has led to the general substitution of other chlorinated hydrocarbon solvents. The toxicity of 1,1,2-trichloroethane has been reviewed by Torkelson and Rowe (1981), U.S. EPA (1981e and 1984v), and NLM (1990).

1,1,2-Trichloroethane is well absorbed by all routes. It is metabolized in the liver, primarily by oxidative dechlorination to products such as chloroacetic acid, which are excreted in the urine. Some of the unmetabolized chemical is exhaled. The toxicity of 1,1,2-trichloroethane is increased by several chemicals including acetone and isopropanol, apparently through metabolic interactions.

The main effect of single doses of 1,1,2-trichloroethane is central nervous system depression. It also causes contact irritation and liver toxicity. 1,1,2-Trichloroethane is much more potent as a liver toxin than the 1,1,1-isomer, but is less potent than carbon tetrachloride and chloroform. The major effect of repeated doses is liver toxicity, but some contact irritation (such as skin lesions after repeated dermal dosing, and irritation of the eyes and mucous membranes from inhalation) and kidney lesions have been reported. Chronic exposure via inhalation has also been shown to result in chronic gastric symptoms, fat deposition in the kidneys, and damage to the lungs. In the two carcinogenesis studies reported, 1,1,2-trichloroethane caused tumors in one strain of mice but not in rats. Therefore, it is considered a possible human carcinogen. No data were found on reproductive and aquatic toxicity studies.

Trichloroethene

Trichloroethene is a widely used solvent, especially for dry cleaning and metal degreasing. It has been reviewed by Torkelson and Rowe (1981), U.S. EPA (1983e and 1984w), NLM (1990), and ATSDR (1988d).

Trichloroethene is well absorbed after inhalation and ingestion, and to some extent through intact skin. It tends to collect in fat. The compound is metabolized in the liver to a variety of metabolites, at least some of which are responsible for much of trichloroethene's toxicity. Metabolites are excreted primarily in the urine. Trichloroethene interacts with a number of other chemicals, including ethanol, generally increasing the severity of effects of both compounds.

Acute exposures cause central nervous system depression and some irritation. Trichloroethene was once used as a surgical anesthetic, but this practice has been abandoned because of side effects -- especially cardiac sensitization to the effects of the body's own control mechanisms, and liver failure, both sometimes fatal. Chronic dosing produces liver and kidney lesions as well as a peripheral neuritis. The chemical was found to be carcinogenic in some animal tests, but no human data are available. There is no evidence of reproductive toxicity in the few tests available.

In aquatic toxicity studies, trichloroethene has shown acute toxicity (48- to 96-hour LC50s) at concentrations of 2 to 85 mg/L in various species. No-effect concentrations for longer exposure of *Daphia magna* have been 10 mg/L (U.S. EPA, 1980j; U.S. EPA, 1983e; Hermens and others, 1985; NLM, 1990).

Vinyl Chloride

Vinyl chloride, or chloroethene, was of little toxicological interest until 1974, when it was first reported as a human carcinogen. Since then there have been many human and animal studies summarized in various reviews (Torkelson and Rowe, 1981; U.S. EPA, 1980e, and 1984i; Williams and Weisburger, 1986; NLM, 1990; ATSDR, 1988b).

Vinyl chloride may enter the body through various routes. Once in the body, it is metabolized and excreted. It is fully absorbed after inhalation and ingestion, but little goes through the skin. It is concentrated in the liver (site of metabolism) and kidney (site of excretion). Vinyl chloride is oxidized to an epoxide and other reactive intermediates, which react further. These intermediates are generally believed to be the active chemical species for the specific toxic effects of vinyl chloride. Excretion is primarily in the urine as conjugates of metabolites with sulfur-containing compounds. Very small amounts are exhaled unchanged.

Vinyl chloride exhibits both acute and chronic effects. Large single doses of vinyl chloride produce central nervous system depression. Early studies of its anesthetic potential found cardiac and circulatory disturbances. Repeated low doses in workers produce a syndrome

called "vinyl chloride disease." This includes acroosteolysis, Raynaud's disease, scleroderma, lung toxicity, thrombocytopenia, and liver toxicity. Chromosomal abnormalities are reported in workers. Liver toxicity seems to be the effect seen at lowest doses.

The most striking effect of vinyl chloride toxicity is the production of hemangiosarcomas, which are extremely rare tumors. These are found in the liver and occasionally elsewhere. Since this has been repeatedly confirmed in worker-exposure studies and animal studies, vinyl chloride is considered a definite human carcinogen. Some studies have also reported vinyl chloride-induced tumors in other organs, especially the brain and, after inhalation, the lungs. One rat study found that prior subchronic dosing with ethanol increased tumor incidence.

There have been reports of reproductive toxicity in exposed workers, but no adverse effects have been seen in animal studies except at quite high doses that produce nonspecific toxic effects. Epidemiological studies in the neighborhoods of vinyl chloride plants have been inconclusive.

There are no data on the aquatic toxicity of vinyl chloride. Its high volatility, with half-lives of hours in natural bodies of water, greatly decreases the possibility of any adverse effects.

Xylene

Xylene, or dimethylbenzene, has three isomers with almost identical properties. Xylene is used widely as a solvent, especially as a less toxic and less volatile substitute for benzene, and as a chemical intermediate. Xylene is found in gasoline and similar petroleum distillates. The effects of xylene have been reviewed in Sandmeyer (1981), U.S. EPA (1984h), ATSDR (1989d), and NLM (1990).

Xylene is rapidly absorbed from the lungs and gastrointestinal tract, and slowly absorbed through the skin. Most absorbed xylene is oxidized in the liver to the corresponding toluic acid and coupled with glycine to make methylhippuric acid, which is excreted in the urine.

The toxicity of xylene is similar to that of toluene. There is some evidence that in humans toluene is more toxic at low doses and xylene is more toxic at high doses. Acute doses produce central nervous system depression and irritation at the contact site. Repeated doses cause lesions at the contact site, a variety of central nervous system effects, and some liver lesions in exposed workers. No specific effects have been seen in limited reproductive toxicity studies in humans and animals. There is no evidence of carcinogenicity in the few animal studies available; the data are inadequate for any conclusions.

Very few aquatic toxicity studies are available. LC50s for fish range from 13,000 $\mu\text{g/L}$ to 42,000 $\mu\text{g/L}$.

BIBLIOGRAPHY

ATSDR, 1987a. Draft Toxicological Profile for Tetrachloroethylene. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987b. Draft Toxicological Profile for Chloroform. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987c. Draft Toxicological Profile for Chromium. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987d. Draft Toxicological Profile for Nickel. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987e. Draft Toxicological Profile for Methylene Chloride. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987f. Draft Toxicological Profile for Di(2-ethylhexyl)phthalate. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987g. Draft Toxicological Profile for Benzo(a)anthracene. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987h. Draft Toxicological Profile for Benzo(a)pyrene. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987i. Draft Toxicological Profile for Benzo(b)fluoranthene. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987j. Draft Toxicological Profile for Chrysene. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1987k. Draft Toxicological Profile for Dibenzo(a,h)anthracene. Agency for Toxic Substances and Disease Registry. 1987.

ATSDR, 1988a. Draft Toxicological Profile for Lead. Agency for Toxic Substances and Disease Registry. 1988.

ATSDR, 1988b. Draft Toxicological Profile for Vinyl Chloride. Agency for Toxic Substances and Disease Registry. 1988.

ATSDR, 1988d. Draft Toxicological Profile for Trichloroethylene. Agency for Toxic Substances and Disease Registry. 1988.

ATSDR, 1989a. Draft Toxicological Profile for Toluene. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989aa. Toxicological Profile for Aldrin/Dieldrin. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989b. Draft Toxicological Profile for Copper. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989c. Draft Toxicological Profile for 1,2-Dichloroethene. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989d. Draft Toxicological Profile for Total Xylenes. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989e. Draft Toxicological Profile for Naphthalene and 2-Methylnaphthalene. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989g. Draft Toxicological Profile for Polycyclic Aromatic Hydrocarbons. Agency for Toxic Substances and Disease Registry. 1989.

ATSDR, 1989h. Toxicological Profile for Chlorobenzene. Agency for Toxic Substances and Disease Registry. 1989.

Andrews, Larry S., and Robert Snyder, 1986. Toxic Effects of Solvents and Vapors, In Casarett and Doull's Toxicology, Curtis D. Klaassen, Mary O. Amdur, and John Doull, Editors, Third Edition. New York, Macmillan.

Birge, W.J. and others, 1980. Aquatic Toxicity Test on Inorganic Elements Occurring in Oil Shale, EPA 600/9-80-022.NTIS. Springfield, Va.

Bradley, R. W. and J.B. Sprague, 1985. Accumulation of Zinc in Rainbow Trout as Influenced by pH, Water Hardness, and Fish Size. *Environ. Toxicol. Chem.* 4:685-694.

Callahan, M.A., and others, 1979, Water Related Environmental Fate of 129 Priority Pollutants. Prepared for U.S. EPA Office of Water Planning and Standards, Washington, D.C., EPA 440/4-79-029b.

Carson, B.L., H.V. Ellis, III, and J.L. McCann, 1986. Toxicology and Biological Monitoring of Metals in Humans. Chelsea, Michigan, Lewis Publishers.

Deichmann, William B., 1981. Halogenated Cyclic Hydrocarbons, in Patty's Industrial Hygiene and Toxicology, George D. Clayton and Florence E. Clayton, Editors. Third Revised Edition, Volume 2A. New York, John Wiley and Sons.

Deichmann, William B., and M.L. Keplinger, 1981. Phenols and Phenolic Compounds in Patty's Industrial Hygiene and Toxicology, George D. Clayton, and Florence E. Clayton, Editors; Third Revised Edition, Volume 2A. New York, John Wiley and Sons.

Eisler, R., 1987. Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Fish and Wildlife Service Contaminant Hazard Reviews, Report No. 10.

Goyers, R.A., 1986. Toxic Effects of Metals, in Casarett and Doull's Toxicology, C.D. Klaassen, M.O. Amdur, and J. Doull, Editors. Third Edition. New York, Macmillan.

Hermens, J., and others, 1984. Quantitative Structure-Activity Relationships and Toxicity Studies of Mixtures of Chemicals with Anaesthetic Potency: Acute Lethal and Sublethal Toxicity of Daphnia magna, *Aquatic Toxicology*, 5, 143-154.

Hermens and others, 1985. Quantitative Structure-Activity Relationships and Mixture Toxicity Studies of Alcohols and Chlorohydrocarbons: Effects on Growth of Daphnia magna. *Aquatic Toxicology* 6:209-217.

Hoffman, H.L., 1983. Petroleum and its Products, In Riegel's Handbook of Industrial Chemistry, James A. Kent, Editor, Eighth Edition. New York, Van Nostrand Reinhold.

- IARC, 1973. Cadmium and Inorganic Cadmium Compounds. IARC Monographs, 2:74-99. International Agency for Research on Cancer. 1973.
- IARC, 1976. Cadmium and Cadmium Compounds. IARC Monographs, 11:39-74. International Agency for Research on Cancer. 1976.
- International Agency for Research on Cancer, 1982. Cadmium and Certain Cadmium Compounds. IARC Monographs, Supplement 4:71-73.
- Krasavage, W.J., J.L. O'Donoghue, and G.D. DiVerencenzo, 1982. Ketones, in Patty's Industrial Hygiene and Toxicology, George D. Clayton and Florence E. Clayton, Editors, Third Revised Edition, Volume 2C. New York, John Wiley and Sons.
- Leland, H. V., 1983. Ultrastructural Changes in the Hepatocytes of Juvenile Rainbow Trout and Mature Brown Trout Exposed to Copper and Zinc. Environ. Toxicol. Chem. 2:353-368.
- McCall, J., and others, 1980, Measurement of Sorption Coefficients of Organic Chemicals and Their Use in Environmental Fate Analysis in Test Protocols for Environmental Fate and Movement of Toxicants. Association of Official Analytical Chemists, 94th Annual Meeting, Washington, DC.
- National Institute for Environmental Health Sciences, 1989. Fifth Annual Report on Carcinogens. NTP-89-239.
- NIOSH, 1984. Cadmium. Current Intelligence Bulletin 42. National Institute of Occupational Safety and Health. 1984.
- NIOSH, 1986. Methylene Chloride. Current Intelligence Bulletin 46. National Institute of Occupational Safety and Health. 1986.
- National Library of Medicine, 1990. Hazardous Substances Databank File, Toxicology Information Network (TOXNET).
- National Research Council, 1980a. Drinking Water and Health, Volume 3, Washington. National Academy Press.
- National Research Council, 1980b. Recommended Dietary Allowances. Ninth Revised Edition. Washington. National Academy Press.
- National Research Council, 1982. Drinking Water and Health. Volume 4. Washington. National Academy Press.
- Needleman, Herbert L., Alan Schell, David Bellinger, Alan Leviton, and Elizabeth N. Allred, 1990. The Long-term Effects of Exposure to Low Doses of Lead in Childhood, An 11-Year Follow-up Report. New England Journal of Medicine, 322:83-88.
- Newsom, Joan, M., 1985. Transport of Organic Compounds Dissolved in Ground Water. Ground Water Monitoring Review, Spring, 28-36.
- Rogan, Walter J., Beth C. Gladen, Kun-Long Hung, Shin-Lan Koong, Ling-yu Shih, James S. Taylor, Ying-Chin Wu, Dorothy Yang, N. Beth Ragan, and Chen-Chin Hsu, 1988. Congenital Poisoning by Polychlorinated Biphenyls and Their Contaminants in Taiwan. Science 241:334-336.

Sandmeyer, Esther E., 1981. Aromatic Hydrocarbons, in Patty's Industrial Hygiene and Toxicology, G.D. Clayton and F.E. Clayton, Editors, Third Revised Edition, Volume 2B. New York, John Wiley and Sons.

Sandmeyer, E.E., and C.J. Kirwin, 1981. Esters in Patty's Industrial Hygiene and Toxicology. G.D. Clayton and F.E. Clayton, Editors, Third Revised Edition, Volume 2B. New York, John Wiley and Sons.

Sanborn, J.R., and others, 1977, The Degradation of Selected Pesticides in Soil: A Review of the Published Literature. U.S. EPA, Office of Research and Development, Cincinnati, Ohio. EPA-600/9-77-022.

Scheinberg, I. Herbert, 1980. Wilson's Disease, in Harrison's Principles of Internal Medicine, K.J. Isselbacher, R.D. Adamas, E. Braunwald, R.G. Petersdorf and J.D. Wilson. Ninth Edition, New York, McGraw-Hill.

Schyutema, etc., 1984. Toxicity of Cadmium in Water and Sediment Slurries to _____ ???

Stokinger, H.G., 1981. The Metals, in Patty's Industrial Hygiene and Toxicology, G.D. Clayton and F.E. Clayton, Editors, Third Revised Edition, Volume 2A. New York, John Wiley and Sons.

Torkelson, T.R., and V.K. Rowe, 1981. Halogenated Aliphatic Hydrocarbons containing Chlorine, Bromine, and Iodine, in Patty's Industrial Hygiene and Toxicology, George D. Clayton and Florence E. Clayton, Editors, Third Revised Edition, Volume 2B. New York, John Wiley & Sons.

U.S. EPA, 1980a. Ambient Water Quality Criteria for Chromium. EPA 440/5-80-035. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980b. Ambient Water Quality Criteria for Polychlorinated Biphenyls. EPA 440/5-80-068. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980d. Ambient Water Quality Criteria for Lead. EPA 440/5-80-079. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980e. Ambient Water Quality Criteria for Vinyl Chloride. EPA 440/5-80-078. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980f. Ambient Water Quality Criteria for Copper. EPA-440/5-80-036, Washington, D.C. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980g. Ambient Water Quality Criteria for Cadmium. EPA 440/5-80-025. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980h. Ambient Water Quality Criteria for Dichloroethylenes. EPA/440/5-80-041. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980i. Ambient Water Quality Criteria for Tetrachloroethylene. EPA 440/5-80-073. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980j. Ambient Water Quality Criteria for Trichloroethylene. EPA 440/5-80-077. U.S. Environmental Protection Agency. 1980.

U.S. EPA, 1980m. An Exposure and Risk Assessment for Phthalate Esters. EPA 440/4-81-020. U.S. Environmental Protection Agency. 1980.

- U.S. EPA, 1981a. An Exposure and Risk Assessment for Toluene, Final Draft Report. U.S. Environmental Protection Agency. 1981.
- U.S. EPA, 1981d. An Exposure and Risk Assessment for Copper. EPA-440/4-81-015. U.S. Environmental Protection Agency. 1981.
- U.S. EPA, 1981e. An Exposure and Risk Assessment for Trichloroethanes. Final Draft Report. U.S. Environmental Protection Agency. 1981.
- U.S. EPA, 1981f. An Exposure and Risk Assessment for Zinc. EPA-440/4-81-016. U.S. Environmental Protection Agency. 1981.
- U.S. EPA, 1982a. Health Assessment Document for Toluene. EPA-600/8-82-008. Washington, D.C. U.S. Environmental Protection Agency. 1982.
- U.S. EPA, 1982b. Health Assessment Document for Tetrachloroethylene (Perchloroethylene) - Draft. EPA 600/8-82-005. U.S. Environmental Protection Agency. 1982.
- U.S. EPA, 1982d. Health Assessment Document for 1,1,1-Trichloroethane (Methyl Chloroform). EPA-600/8-82-003. U.S. Environmental Protection Agency. 1982.
- U.S. EPA, 1982e. An Exposure and Risk Assessment for Benzo(a)pyrene and Other Polycyclic Aromatic Hydrocarbons. Office of Water Regulations and Standards (WH-533), Washington, D.C. U.S. Environmental Protection Agency. 1982.
- U.S. EPA, 1982f. Errata: PAH Ambient Water Quality Criterion for the Protection of Human Health. Environmental Criteria and Assessment Office (ECAO-CIN-D024), Cincinnati, OH. U.S. Environmental Protection Agency. 1982.
- U.S. EPA, 1983b. Ambient Water Quality Criteria for Lead, Draft, August 19, 1983. Washington, D.C. U.S. Environmental Protection Agency. 1983.
- U.S. EPA, 1983d. Health Assessment Document for Tetrachloroethylene. Review Draft, EPA 600/8-82-005B. U.S. Environmental Protection Agency. 1983.
- U.S. EPA, 1983e. Health Assessment Documents for Trichloroethylene. EPA 600/8-82-0066B. U.S. Environmental Protection Agency. 1983.
- U.S. EPA, 1984a. Air Quality Criteria for Lead. EPA 600-8-83-028B. U.S. Environmental Protection Agency. 1984.
- U.S. EPA, 1984b. Health Effects Assessment for Toluene. ECAO-CIN-H033. U.S. Environmental Protection Agency. 1984.
- U.S. EPA, 1984e. Health Effects Assessment for Polychlorinated Biphenyls. ECAO-CIN-H004. U.S. Environmental Protection Agency. 1984.
- U.S. EPA, 1984f. Health Effects Assessment for Chromium. ECAO-CIN-H020. U.S. Environmental Protection Agency. 1984.
- U.S. EPA, 1984h. Health Effects Assessment for Xylene. Cincinnati, OH EPA/540/1-86-006. U.S. Environmental Protection Agency. 1984.
- U.S. EPA, 1984i. Health Effects Assessment for Vinyl Chloride. ECAO-CIN-H036. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984k. Health Effects Assessment for Copper, ECAO-CIN-H025. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984l. Health Effects Assessment for Cadmium. ECAO-CIN-H038. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984m. Health Effects Assessment for cis-1,2-Dichloroethylene ECAO-CIN-H015. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984n. Health Effects Assessment for 1,2-t-Dichloroethylene. ECAO-CIN-H041. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984o. Health Effects Assessment for Chloroform. ECAO-CIN-H010. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984p. Health Effects Assessment for 1,1-Dichloroethane, ECAA-CIN-H027. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984q. Health Effects Assessment for Methylene Chloride. ECAO-CIN-H028. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984r. Health Effects Assessment for 1,1-Dichloroethylene, ECAO-CIN-H051. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984s. Health Effects Assessment for Ethylbenzene. ECAO-CIN-H008. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984t. Health Effects Assessment for Tetrachloroethylene. ECAO-CIN-H021. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984u. Health Effects Assessment for 1,1,1-Trichloroethane. ECAO-CIN-H005. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984v. Health Effects Assessment for 1,1,2-Trichloroethane. ECAO-CIN-H045. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984w. Health Effects Assessment for Trichloroethylene. ECAO-CIN-H046. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984x. Health Effects Assessment for Methyl Ethyl Ketone. ECAO-CIN-H003. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984y. Health Assessment Document for Chromium. EPA-0600/8-83-014F. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984z. Health Effects Assessment for Polycyclic Aromatic Hydrocarbons (PAH). ECAO-CIN-H013. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984cc. Health Effects Assessment for Zinc (and compounds). ECAO-CIN-H048. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984dd. Health Effects Assessment for Phenol. ECAO-CIN-H007. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984ee. Health Effects Assessment for Acetone. ECAO-CIN-H016. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1984ff. Health Effects Assessment for Chlorobenzene. ECAO - CIN - H040. U.S. Environmental Protection Agency. 1984.

U.S. EPA, 1985a. Ambient Aquatic Life Water Quality Criteria for Copper. EPA-440/5-84-031. U.S. Environmental Protection Agency. 1985.

U.S. EPA, 1985aa. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Final Report. Clement Associates, Inc. Arlington, VA.

U.S. EPA, 1985b. Ambient Aquatic Life Water Quality for Cadmium. EPA 440/5-84-032. U.S. Environmental Protection Agency. 1985.

U.S. EPA, 1985c. Health Assessment Document for Chloroform. EPA/600/8-84/004F. U.S. Environmental Protection Agency. 1985.

U.S. EPA, 1985d. Updated Mutagenicity and Carcinogenicity Assessment of Cadmium. EPA/600/6-83/025F. U.S. Environmental Protection Agency. 1985.

U.S. EPA, 1985e. Health Assessment Document for Dichloromethane (Methylene Chloride). EPA/600/8-82/004FF. U.S. Environmental Protection Agency. 1985.

U.S. EPA, 1985f. Updated Carcinogenicity Assessment of Dichloromethane (Methylene Chloride). EPA/600/6-82/004F. U.S. Environmental Protection Agency. 1985.

U.S. EPA, 1986c. Addendum to the Health Assessment Document for Tetrachloroethylene. Review Draft, EPA/600/8-82/005FA. U.S. Environmental Protection Agency. 1986.

U.S. EPA, 1987a. Technical Analysis of New Methods and Data Regarding Dichloromethane Hazard Assessments. EPA/600/8-87/029A. U.S. Environmental Protection Agency. 1987.

U.S. EPA, 1987aa. Health Advisories for 50 Pesticides. EPA, Office of Drinking Water, Washington, D.C.

U.S. EPA, 1987b. Update to the Health Assessment Document and Addendum for Dichloromethane (Methylene Chloride): Pharmacokinetics, Mechanism of Action and Epidemiology. EPA/600/8-87/030A. U.S. Environmental Protection Agency. 1987b.

U.S. EPA, 1987c. Ambient Water Quality Criteria for Zinc. EPA-440/5-87-003. U.S. Environmental Protection Agency. 1987.

U.S. EPA, 1988b. Air Quality Criteria for Lead. EPA 600-8-83-028B. U.S. Environmental Protection Agency. 1988.

U.S. EPA, 1988c. Drinking Water Regulations; Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper; Proposed Rule. Federal Register, 53; 3156-31578. U.S. Environmental Protection Agency. 1988.

U.S. EPA, 1989. Health Effects Assessment for Polycyclic Aromatic Hydrocarbons (PAH). Final Draft, ECAO-CIN-H013. U.S. Environmental Protection Agency. 1989.

U.S. EPA, 1990. Integrated Risk Information System Database (IRIS), Toxicology Information Network (TOXNET). U.S. Environmental Protection Agency. 1990.

Veith, G. D., and others, 1979. Measuring and Estimating the Bioconcentration Factor of Chemicals in Fish. Fish Res. Board Can. 36:1040-1048.

Williams, Gary M., and John H. Weisburger, 1986. Chemical Carcinogens, in Casarett and Doull's Toxicology. C.D. Klaassen, M.O. Amdur, and J. Doull), Editors, Third Edition, New York, Macmillan.

APPENDIX I
PERMEABILITY CONSTANTS

**TABLE I-1
CHEMICAL-SPECIFIC PERMEABILITY FACTORS**

Chemical	Permeability Factors for Dermal Contact with Contaminated Water (cm/hr)
Di-n-butyl phthalate	3.3×10^{-3}
Chromium	1.0×10^{-3}
Zinc	6.0×10^{-4}
1,1-Dichloroethene	1.6×10^{-3}
1,1-Dichloroethane	8.9×10^{-3}
1,2-Dichloroethene	1.0×10^{-3}
1,1,1-Trichloroethane	1.7×10^{-3}
Vinylchloride	7.3×10^{-3}
Trans-1,3-Dichloropropene	5.5×10^{-3}
Toluene	4.5×10^{-3}
Ethybenzene	7.4×10^{-3}
Phenanthrene	2.3×10^{-1}
Anthracene	$8.4 \times 10^{-4} *$
Fluoranthene	3.6×10^{-1}
Pyrene	$8.4 \times 10^{-4} *$
Benzo(a) anthracene	8.1×10^{-1}
Chrysene	8.1×10^{-1}
Benzo(b) fluoranthene	1.2×10^0
Benzo(k) fluoroanthene	$8.4 \times 10^{-4} *$
Indeno(1,2,3,c,d) perylene	1.9×10^0
Benzo(g, h, i) perylene	$8.4 \times 10^{-4} *$
Lead	4.0×10^{-4}
Trichloroethene	1.6×10^{-3}
Chloroform	8.9×10^{-3}
Total Xylenes	8.0×10^{-3}
Naphthalene	6.9×10^{-3}
2-Methylnaphthalene	$8.4 \times 10^{-4} *$
Fluorene	$8.4 \times 10^{-4} *$
Chlordane	5.2×10^{-3}
PCB	7.1×10^{-1}
Beryllium	$8.4 \times 10^{-4} *$
Cadmium	1.0×10^{-3}

* default PC for water

APPENDIX J
RISK TABLES

Table J-1
 Lenz Oil Baseline Risk Assessment
 Recreational/surface water/ingestion
 Adult

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
pyrene	2.00E-03	3E-02	4.7E-01	1.37E-08	5.87E-09	4.57E-07	2.76E-09
beryllium	1.35E-03	5E-03		9.25E-09	3.96E-09	1.85E-06	0.00E+00
cadmium	1.52E-02	5E-04		1.04E-07	4.46E-08	2.08E-04	0.00E+00
Total-adult						2.11E-04	2.76E-09

recreational-young adult/child

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
pyrene	2.00E-03	3E-02	4.7E-01	1.11E-08	4.76E-09	3.70E-07	2.24E-09
beryllium	1.35E-03	5E-03		7.50E-09	3.21E-09		0.00E+00
cadmium	1.52E-02	5E-04		8.44E-08	3.62E-08	1.69E-04	0.00E+00
Total-child						1.69E-04	2.24E-09
Total-adult/child						3.80E-04	5.00E-09

Table J-2

Lenz Oil Baseline Risk Assessment

Recreational/surface water/dermal contact – exposure in ditch

Adult

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
pyrene	2.00E-03	3E-02	4.7E-01	3.51E-10	1.50E-10	1.17E-08	7.07E-11
beryllium	1.35E-03	5E-03		2.37E-10	1.02E-10	4.74E-08	0.00E+00
cadmium	1.52E-02	5E-04		2.67E-09	1.14E-09	5.33E-06	0.00E+00
Total-adult						5.39E-06	7.07E-11

recreational-young adult/child

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
pyrene	2.00E-03	3E-02	4.7E-01	4.11E-10	1.76E-10	1.37E-08	8.27E-11
beryllium	1.35E-03	5E-03		2.77E-10	1.19E-10	5.55E-08	0.00E+00
cadmium	1.52E-02	5E-04		3.12E-09	1.34E-09	6.24E-06	0.00E+00
Total-young adult/child						6.31E-06	8.27E-11
TOTAL-adult/young adult/child						1.17E-05	1.53E-10

Table J-3

Lenz Oil Baseline Risk Assessment

Recreational/surface water/dermal contact – whole body exposure

Adult

Chemicals	Conc. (mg/l)	RfD (mg/kg – day)	SF(mg/kg – day) – 1	Intake – NC (mg/kg – day)	Intake – CAR (mg/kg – day)	HQ	Risk
pyrene	2.00E – 03	3E – 02	4.7E – 01	2.30E – 09	9.86E – 10	7.67E – 08	4.64E – 10
beryllium	1.35E – 03	5E – 03		1.55E – 09	6.66E – 10	3.11E – 07	0.00E + 00
cadmium	1.52E – 02	5E – 04		1.75E – 08	7.50E – 09	3.50E – 05	0.00E + 00
Total – adult						3.54E – 05	4.64E – 10

recreational – young adult/child

Chemicals	Conc. (mg/kg)	RfD (mg/kg – day)	SF(mg/kg – day) – 1	Intake – NC (mg/kg – day)	Intake – CAR (mg/kg – day)	HQ	Risk
pyrene	2.00E – 03	3E – 02	4.7E – 01	1.11E – 09	4.76E – 10	3.70E – 08	2.24E – 10
beryllium	1.35E – 03	5E – 03		7.49E – 10	3.21E – 10	1.50E – 07	0.00E + 00
cadmium	1.52E – 02	5E – 04		8.44E – 09	3.62E – 09	1.69E – 05	0.00E + 00
Total – young adult/child						1.69E – 05	2.24E – 10
TOTAL – adult/young adult/child						5.23E – 05	6.87E – 10

Table J-4
 Lenz Oil Baseline Risk Assessment
 Recreational/sediment/dermal contact
 Adult

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
acetone	1.80E-01	1E-01		4.83E-09	2.07E-09	4.83E-08	0.00E+00
xylenes total	8.80E-02	2E+00		2.36E-09	1.01E-09	1.18E-09	0.00E+00
naphthalene	1.29E+00	4E-02		1.38E-08	5.93E-09	3.46E-07	0.00E+00
methylnaphthalene,2	4.40E-01			4.72E-09	2.02E-09		0.00E+00
acenaphthene	1.29E+00	6E-02		1.38E-08	5.93E-09	2.31E-07	0.00E+00
dibenzofuran	1.22E+00			1.30E-08	5.59E-09		0.00E+00
fluorene	1.74E+00	4E-02		1.87E-08	8.02E-09	4.68E-07	0.00E+00
butylbenzyl phthalate	3.55E-01	2.00E-01		3.81E-09	1.63E-09	1.90E-08	0.00E+00
bis(2-ethylhexyl)phthalate	7.30E-01	2E-02	1.4E-02	7.83E-09	3.36E-09	3.92E-07	4.70E-11
benzo(k)flouranthene	2.10E+00		3.8E-01	2.25E-08	9.65E-09		3.67E-09
benzo(a)pyrene	2.38E+00		5.8E+00	2.55E-08	1.09E-08		6.35E-08
cobalt	3.12E+01			3.35E-08	1.43E-08		0.00E+00
copper	1.40E-01			1.50E-10	6.44E-11		0.00E+00
Total-adult						1.50E-06	6.72E-08

recreational-young adult/child

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
acetone	1.80E-01	1E-01		7.43E-09	3.19E-09	7.43E-08	0.00E+00
xylenes total	8.80E-02	2E+00		3.63E-09	1.56E-09	1.82E-09	0.00E+00
naphthalene	1.29E+00	4E-02		2.13E-08	9.14E-09	5.33E-07	0.00E+00
methylnaphthalene,2	4.40E-01			7.27E-09	3.11E-09		0.00E+00
acenaphthene	1.29E+00	6E-02		2.13E-08	9.14E-09	3.55E-07	0.00E+00
dibenzofuran	1.22E+00			2.01E-08	8.60E-09		0.00E+00
fluorene	1.74E+00	4E-02		2.88E-08	1.23E-08	7.20E-07	0.00E+00
butylbenzyl phthalate	3.55E-01	2.00E-01		5.86E-09	2.51E-09	2.93E-08	0.00E+00
bis(2-ethylhexyl)phthalate	7.30E-01	2E-02	1.4E-02	1.21E-08	5.17E-09	6.03E-07	7.23E-11
benzo(k)flouranthene	2.10E+00		3.8E-01	3.47E-08	1.49E-08		5.65E-09
benzo(a)pyrene	2.38E+00		5.8E+00	3.93E-08	1.69E-08		9.78E-08
cobalt	3.12E+01			5.15E-08	2.21E-08		0.00E+00
copper	1.40E-01			2.31E-10	9.91E-11		0.00E+00
Total-young adult/child						2.32E-06	1.04E-07

TOTAL -	1/child					3.82E-06	1.71E-07
---------	---------	--	--	--	--	----------	----------

Table J-5
 Lenz Oil Baseline Risk Assessment
 Trespasser/soil/ingestion/nonexcavated area (B)
 Adult

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		2.82E-10	1.21E-10	4.70E-09	0.00E+00
acetone	7.57E-02	1E-01		2.07E-09	8.89E-10	2.07E-08	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		9.59E-11	4.11E-11	9.59E-10	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		1.69E-10	7.23E-11	8.44E-09	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	2.00E-10	8.57E-11		7.80E-12
trichloroethane,1,1,1	2.58E-02	9E-02		7.07E-10	3.03E-10	7.85E-09	0.00E+00
dichloropropene,1,3,T	5.90E-02	3E-04		1.62E-09	6.93E-10	5.39E-06	0.00E+00
trichloroethene	4.01E-02		1.1E-02	1.10E-09	4.71E-10		5.18E-12
Benzene	5.99E-03		3E-02	1.64E-10	7.03E-11		2.04E-12
methyl,4-2-pentanone	6.12E-03			1.68E-10	7.19E-11		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	6.25E-10	2.68E-10	6.25E-08	1.37E-11
toluene	6.94E-03	2E-01		1.90E-10	8.15E-11	9.51E-10	0.00E+00
ethylbenzene	1.14E-02	1E-01		3.12E-10	1.34E-10	3.12E-09	0.00E+00
xylenes (total)	2.15E-02	2E+00		5.89E-10	2.52E-10	2.95E-10	0.00E+00
naphthalene	8.20E-02	4E-02		2.25E-09	9.63E-10	5.62E-08	0.00E+00
methnaphthalene,2	7.70E-02			2.11E-09	9.04E-10		0.00E+00
acenaphthene	1.40E-01	6E-02		3.84E-09	1.64E-09	6.39E-08	0.00E+00
dibenzofuran	1.20E-01			3.29E-09	1.41E-09		0.00E+00
fluorene	2.21E-01	4E-02		6.05E-09	2.59E-09	1.51E-07	0.00E+00
phenanthrene	5.47E-01			1.50E-08	6.42E-09		0.00E+00
anthracene	2.75E-01	3E-01		7.53E-09	3.23E-09	2.51E-08	0.00E+00
fluoranthene	7.88E-01	4E-02		2.16E-08	9.25E-09	5.40E-07	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	1.80E-08	7.73E-09	6.01E-07	3.63E-09
butylbenzylphthalate	2.29E-01	2E-01		6.27E-09	2.69E-09	3.14E-08	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	1.28E-08	5.51E-09		4.63E-09
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	4.38E-09	1.88E-09	2.19E-07	2.63E-11
chrysene	4.34E-01		2.5E-02	1.19E-08	5.10E-09		1.27E-10
benzo(b)fluoranthene	4.54E-01		8.1E-01	1.24E-08	5.33E-09		4.33E-09
benzo(k)fluoranthene	4.35E-01		3.8E-01	1.19E-08	5.11E-09		1.96E-09
benzo(a)pyrene	4.54E-01		5.8E+00	1.24E-08	5.33E-09		3.09E-08
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	7.67E-09	3.29E-09		4.44E-09
benzo(g,h,i)perylene	2.88E-01		1.3E-01	7.89E-09	3.38E-09		4.33E-10
Gamma-BHC	1.30E-03	3E-04		3.56E-11	1.53E-11	1.19E-07	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	5.21E-11	2.23E-11	1.74E-06	3.79E-10
endosulfan I	5.20E-03			1.42E-10	6.11E-11		0.00E+00
DDE	2.10E-02		3.4E+01	5.75E-10	2.47E-10		8.38E-09
DDD	9.94E-03		2.4E+01	2.72E-10	1.17E-10		2.80E-09
DDT	1.28E-02	5E-04	3.4E-01	3.51E-10	1.50E-10	7.01E-07	5.11E-11
alpha chlordane	3.11E-03	6E-05	1.3E+00	8.52E-11	3.65E-11	1.42E-06	4.75E-11
gamma chlordane	2.94E-03	6E-05	1.3E+00	8.05E-11	3.45E-11	1.34E-06	4.49E-11
rochlor-1242	1.42E-01		7.7E+00	3.89E-09	1.67E-09		1.28E-08
rochlor-1254	6.02E-02		7.7E+00	1.65E-09	7.07E-10		5.44E-09
calcium	1.01E+05			2.77E-03	1.19E-03		0.00E+00
chromium	3.33E+01	1E+00		9.12E-07	3.91E-07	9.12E-07	0.00E+00
lead	3.53E+02			9.67E-06	4.14E-06		0.00E+00
magnesium	5.65E+04			1.55E-03	6.63E-04		0.00E+00
cadmium	1.03E+00	1E-03		2.82E-08	1.21E-08	2.82E-05	0.00E+00
Total-adult						4.16E-05	8.05E-08

Table J-5 (continued)
 Lenz Oil Baseline Risk Assessment
 Trespasser soil ingestion - child

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		2.29E-10	9.81E-11	3.81E-09	0.00E+00
acetone	7.57E-02	1E-01		1.68E-09	7.21E-10	1.68E-08	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		7.77E-11	3.33E-11	7.77E-10	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		1.37E-10	5.86E-11	6.84E-09	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	1.62E-10	6.95E-11		6.32E-12
trichloroethane,1,1,1	2.58E-02	9E-02		5.73E-10	2.46E-10	6.37E-09	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		1.31E-10	5.62E-11	4.37E-07	0.00E+00
trichloroethene	4.01E-02		1.1E-02	8.91E-10	3.82E-10		4.20E-12
Benzene	5.99E-03		3E-02	1.33E-10	5.70E-11		1.71E-12
methyl,4-2-pentanone	6.12E-03			1.36E-10	5.83E-11		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	5.06E-10	2.17E-10	5.06E-08	1.11E-11
toluene	6.94E-03	2E-01		1.54E-10	6.61E-11	7.71E-10	0.00E+00
ethylbenzene	1.14E-02	1E-01		2.53E-10	1.09E-10	2.53E-09	0.00E+00
xylene (total)	2.15E-02	2E+00		4.78E-10	2.05E-10	2.39E-10	0.00E+00
naphthalene	8.20E-02	4E-02		1.82E-09	7.81E-10	4.55E-08	0.00E+00
methnaphthalene,2	7.70E-02			1.71E-09	7.33E-10		0.00E+00
acenaphthene	1.40E-01	6E-02		3.11E-09	1.33E-09	5.18E-08	0.00E+00
dibenzofuran	1.20E-01			2.67E-09	1.14E-09		0.00E+00
fluorene	2.21E-01	4E-02		4.91E-09	2.10E-09	1.23E-07	0.00E+00
phenanthrene	5.47E-01			1.22E-08	5.21E-09		0.00E+00
anthracene	2.75E-01	3E-01		6.11E-09	2.62E-09	2.04E-08	0.00E+00
fluoranthene	7.88E-01	4E-02		1.75E-08	7.50E-09	4.38E-07	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	1.46E-08	6.26E-09	4.87E-07	2.94E-09
butylbenzylphthalate	2.29E-01	2E-01		5.09E-09	2.18E-09	2.54E-08	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	1.04E-08	4.47E-09		3.76E-09
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	3.55E-09	1.52E-09	1.78E-07	2.13E-11
chrysene	4.34E-01		2.5E-02	9.64E-09	4.13E-09		1.03E-10
benzo(b)fluoranthene	4.54E-01		8.1E-01	1.01E-08	4.32E-09		3.51E-09
benzo(k)fluoranthene	4.35E-01		3.8E-01	9.66E-09	4.14E-09		1.59E-09
benzo(a)pyrene	4.54E-01		5.8E+00	1.01E-08	4.32E-09		2.51E-08
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	6.22E-09	2.67E-09		3.60E-09
benzo(g,h,i)perylene	2.88E-01		1.3E-01	6.40E-09	2.74E-09		3.51E-10
Gamma-BHC	1.30E-03	3E-04		2.89E-11	1.24E-11	9.63E-08	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	4.22E-11	1.81E-11	1.41E-06	3.08E-11
endosulfan I	5.20E-03			1.16E-10	4.95E-11		0.00E+00
DDE	2.10E-02		3.4E+01	4.66E-10	2.00E-10		6.80E-09
DDD	9.94E-03		2.4E+01	2.21E-10	9.46E-11		2.27E-09
DDT	1.28E-02	5E-04	3.4E-01	2.84E-10	1.22E-10	5.69E-07	4.14E-11
alpha chlordane	3.11E-03	6E-05	1.3E+00	6.91E-11	2.96E-11	1.15E-06	3.85E-11
gamma chlordane	2.94E-03	6E-05	1.3E+00	6.53E-11	2.80E-11	1.09E-06	3.64E-11
aro chlor-1242	1.42E-01		7.7E+00	3.15E-09	1.35E-09		1.04E-08
aro chlor-1254	6.02E-02		7.7E+00	1.34E-09	5.73E-10		4.41E-09
calcium	1.01E+05			2.24E-03	9.62E-04		0.00E+00
chromium	3.33E+01	1E+00		7.40E-07	3.17E-07	7.40E-07	0.00E+00
lead	3.53E+02			7.84E-06	3.36E-06		0.00E+00
magnesium	5.65E+04			1.26E-03	5.38E-04		0.00E+00
cadmium	1.03E+00	1E-03		2.29E-08	9.81E-09	2.29E-05	0.00E+00
Total-child						2.98E-05	6.53E-08
Total Adult/Child						7.15E-05	1.46E-07

Table J-6
 Lenz Oil Baseline Risk Assessment
 Trespasser/soil/dermal/nonexcavated area (B)
 Adult

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		3.53E-09	1.51E-09	5.88E-08	0.00E+00
acetone	7.57E-02	1E-01		2.59E-08	1.11E-08	2.59E-07	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		1.20E-09	5.14E-10	1.20E-08	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		2.11E-09	9.04E-10	1.05E-07	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	2.50E-09	1.07E-09		9.75E-11
trichloroethane,1,1,1	2.58E-02	9E-02		8.84E-09	3.79E-09	9.82E-08	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		2.02E-09	8.66E-10	6.74E-06	0.00E+00
trichloroethene	4.01E-02		1.1E-02	1.37E-08	5.89E-09		6.47E-11
Benzene	5.99E-03		2.9E-02	2.05E-09	8.79E-10		2.55E-11
methyl,4-2-pentanone	6.12E-03			2.10E-09	8.98E-10		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	7.81E-09	3.35E-09	7.81E-07	1.71E-10
toluene	6.94E-03	2E-01		2.38E-09	1.02E-09	1.19E-08	0.00E+00
ethylbenzene	1.14E-02	1E-01		3.90E-09	1.67E-09	3.90E-08	0.00E+00
xylene (total)	2.15E-02	2E+00		7.36E-09	3.16E-09	3.68E-09	0.00E+00
naphthalene	8.20E-02	4E-02		1.12E-08	4.81E-09	2.81E-07	0.00E+00
methnaphthalene,2	7.70E-02			1.05E-08	4.52E-09		0.00E+00
acenaphthene	1.40E-02	6E-02		1.92E-09	8.22E-10	3.20E-08	0.00E+00
dibenzofuran	1.20E-01			1.64E-08	7.05E-09		0.00E+00
fluorene	2.22E-01	4E-02		3.04E-08	1.30E-08	7.61E-07	0.00E+00
phenanthrene	5.47E-01			7.49E-08	3.21E-08		0.00E+00
anthracene	2.75E-01	3E-01		3.77E-08	1.61E-08	1.26E-07	0.00E+00
fluoranthene	7.88E-01	4E-02		1.08E-07	4.63E-08	2.70E-06	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	9.01E-08	3.86E-08	3.00E-06	1.82E-08
butylbenzylphthalate	2.29E-01	2E-01		3.14E-08	1.34E-08	1.57E-07	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	6.42E-08	2.75E-08		2.32E-08
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	2.19E-08	9.39E-09	1.10E-06	1.32E-10
chrysene	4.34E-01		2.5E-02	5.95E-08	2.55E-08		6.37E-10
benzo(b)fluoranthene	4.54E-01		8.1E-01	6.22E-08	2.67E-08		2.16E-08
benzo(k)fluoranthene	4.35E-01		3.8E-01	5.96E-08	2.55E-08		9.78E-09
benzo(a)pyrene	4.54E-01		5.8E+00	6.22E-08	2.67E-08		1.55E-07
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	3.84E-08	1.64E-08		2.22E-08
benzo(g,h,i)perylene	2.88E-01		1.3E-01	3.95E-08	1.69E-08		2.16E-09
Gamma-BHC	1.30E-03	3E-04		1.78E-10	7.63E-11	5.94E-07	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	2.60E-10	1.12E-10	8.68E-06	1.90E-09
endosulfan I	5.20E-03			7.12E-10	3.05E-10		0.00E+00
DDE	2.10E-02		3.4E+01	2.88E-09	1.23E-09		4.19E-08
DDD	9.94E-03		2.4E+01	1.36E-09	5.84E-10		1.40E-08
DDT	1.28E-02	5E-04	3.4E-01	1.75E-09	7.51E-10	3.51E-06	2.55E-10
alpha chlordane	3.11E-03	6E-05	1.3E+00	4.26E-10	1.83E-10	7.10E-06	2.37E-10
gamma chlordane	2.94E-03	6E-05	1.3E+00	4.03E-10	1.73E-10	6.71E-06	2.24E-10
rochlor-1242	1.42E-01		7.7E+00	1.95E-08	8.34E-09		6.42E-08
rochlor-1254	6.02E-02		7.7E+00	8.25E-09	3.53E-09		2.72E-08
calcium	1.01E+05			1.38E-03	5.93E-04		0.00E+00
chromium	4.33E+00	1E+00		5.93E-08	2.54E-08	5.93E-08	0.00E+00
lead	5.53E+00			7.58E-08	3.25E-08		0.00E+00
magnesium	9.65E+00			1.32E-07	5.67E-08		0.00E+00
cadmium	1.03E+00	1E-03		1.41E-08	6.05E-09	1.41E-05	0.00E+00
Total-adult						5.70E-05	4.03E-07

Table J-6 (continued)
 Lenz Oil Baseline Risk Assessment
 Trespasser soil dermal - children

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		1.70E-09	7.29E-10	2.84E-08	0.00E+00
acetone	7.57E-02	1E-01		1.25E-08	5.36E-09	1.25E-07	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		5.78E-10	2.48E-10	5.78E-09	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		1.02E-09	4.36E-10	5.09E-08	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	1.21E-09	5.17E-10		4.70E-11
trichloroethane,1,1,1	2.58E-02	9E-02		4.26E-09	1.83E-09	4.74E-08	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		9.75E-10	4.18E-10	3.25E-06	0.00E+00
trichloroethene	4.01E-02		1.1E-02	6.63E-09	2.84E-09		3.12E-11
Benzene	5.99E-03		2.9E-02	9.90E-10	4.24E-10		1.23E-11
methyl,4-2-pentanone	6.12E-03			1.01E-09	4.33E-10		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	3.77E-09	1.61E-09	3.77E-07	8.23E-11
toluene	6.94E-03	2E-01		1.15E-09	4.91E-10	5.73E-09	0.00E+00
ethylbenzene	1.14E-02	1E-01		1.88E-09	8.07E-10	1.88E-08	0.00E+00
xylene (total)	2.15E-02	2E+00		3.55E-09	1.52E-09	1.78E-09	0.00E+00
naphthalene	8.20E-02	4E-02		5.42E-09	2.32E-09	1.35E-07	0.00E+00
methnaphthalene,2	7.70E-02			5.09E-09	2.18E-09		0.00E+00
acenaphthene	1.40E-01	6E-02		9.25E-09	3.97E-09	1.54E-07	0.00E+00
dibenzofuran	1.20E-01			7.93E-09	3.40E-09		0.00E+00
fluorene	2.21E-01	4E-02		1.46E-08	6.26E-09	3.65E-07	0.00E+00
phenanthrene	5.47E-01			3.61E-08	1.55E-08		0.00E+00
anthracene	2.75E-01	3E-01		1.82E-08	7.79E-09	6.06E-08	0.00E+00
fluoranthene	7.88E-01	4E-02		5.21E-08	2.23E-08	1.30E-06	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	4.35E-08	1.86E-08	1.45E-06	8.76E-09
butylbenzylphthalate	2.29E-01	2E-01		1.51E-08	6.49E-09	7.57E-08	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	3.10E-08	1.33E-08		1.12E-08
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	1.06E-08	4.53E-09	5.29E-07	6.34E-11
chrysene	4.34E-01		2.5E-02	2.87E-08	1.23E-08		3.07E-10
benzo(b)fluoranthene	4.54E-01		8.1E-01	3.00E-08	1.29E-08		1.04E-08
benzo(k)fluoranthene	4.35E-01		3.8E-01	2.87E-08	1.23E-08		4.72E-09
benzo(a)pyrene	4.54E-01		5.8E+00	3.00E-08	1.29E-08		7.46E-08
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	1.85E-08	7.93E-09		1.07E-08
benzo(g,h,i)perylene	2.88E-01		1.3E-01	1.90E-08	8.16E-09		1.04E-09
Gamma-BHC	1.30E-03	3E-04		8.59E-11	3.68E-11	2.86E-07	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	1.26E-10	5.38E-11	4.19E-06	9.15E-1
endosulfan I	5.20E-03			3.44E-10	1.47E-10		0.00E+00
DDE	2.10E-02		3.4E+01	1.39E-09	5.95E-10		2.02E-08
DDD	9.94E-03		2.4E+01	6.57E-10	2.82E-10		6.76E-09
DDT	1.28E-02	5E-04	3.4E-01	8.46E-10	3.63E-10	1.69E-06	1.23E-10
alpha chlordane	3.11E-03	6E-05	1.3E+00	2.06E-10	8.81E-11	3.43E-06	1.15E-10
gamma chlordane	2.94E-03	6E-05	1.3E+00	1.94E-10	8.33E-11	3.24E-06	1.08E-10
aro chlor-1242	1.42E-01		7.7E+00	9.38E-09	4.02E-09		3.10E-08
aro chlor-1254	6.02E-02		7.7E+00	3.98E-09	1.71E-09		1.31E-08
calcium	1.01E+05			6.67E-04	2.86E-04		0.00E+00
chromium	3.33E+01	1E+00		2.20E-07	9.43E-08	2.20E-07	0.00E+00
lead	3.53E+02			2.33E-06	1.00E-06		0.00E+00
magnesium	5.65E+04			3.73E-04	1.60E-04		0.00E+00
cadmium	1.03E+00	1E-03		6.81E-09	2.92E-09	6.81E-06	0.00E+00
Total-child						2.78E-05	1.94E-07
TOTAL-adult/child						8.49E-05	5.97E-07

Table J-7

Lenz Oil Baseline Risk Assessment
Inhalation/trespasser/adults/area B
dispersion model

Chemical	Conc. (mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.82E-03			4.78E-06	2.05E-06		0.00E+00
acetone	5.43E-02			4.46E-05	1.91E-05		0.00E+00
dichloroethane,1,1	8.45E-03			6.95E-06	2.98E-06		0.00E+00
dichloroethane,1,2	3.01E-03			2.47E-06	1.06E-06		0.00E+00
dichloroethane,1,2	5.38E-03		9.10E-02	4.42E-06	1.90E-06		1.72E-07
trichloroethane,1,1,1	1.26E-02			1.04E-05	4.44E-06		0.00E+00
dichloropropane,1,2	1.30E-03	1.00E-03		1.07E-06	4.58E-07	1.07E-03	0.00E+00
trichloroethene	3.48E-02		1.7E-02	2.86E-05	1.23E-05		2.08E-07
tetrachloroethene	9.93E-02		1.8E-03	8.16E-05	3.50E-05		6.30E-08
toluene	6.84E-03	4E-01		5.62E-06	2.41E-06	1.41E-05	0.00E+00
ethylbenzene	4.10E-03	3E-01		3.37E-06	1.44E-06	1.12E-05	0.00E+00
xylene(total)	9.07E-03			7.45E-06	3.19E-06		0.00E+00
naphthalene	4.00E-02			3.29E-05	1.41E-05		0.00E+00
fluorene	2.31E-03			1.90E-06	8.14E-07		0.00E+00
anthracene	1.25E-04			1.03E-07	4.40E-08		0.00E+00
fluoranthene	1.16E-04			9.53E-08	4.09E-08		0.00E+00
pyrene	5.35E-07		4.9E-01	4.40E-10	1.88E-10		9.31E-11
dichlorobenzidine,3,3	1.00E-06			8.22E-10	3.52E-10		0.00E+00
butylbenzylphthalate	1.16E-03			9.51E-07	4.08E-07		0.00E+00
benzo(a)anthracene	1.09E-03		8.8E-01	8.95E-07	3.84E-07		3.39E-07
bis-(2-ethylhexyl)phthalate	1.06E-03			8.71E-07	3.73E-07		0.00E+00
chrysene	7.37E-06		2.7E-02	6.06E-09	2.60E-09		7.01E-11
benzo(b)fluoranthene	4.31E-01		8.5E-01	3.54E-04	1.52E-04		1.30E-04
benzo(k)fluoranthene	6.71E-02		4.0E-01	5.52E-05	2.37E-05		9.53E-06
benzo(a)pyrene	1.32E-04		6.1E+00	1.08E-07	4.65E-08		2.84E-07
indeno(1,2,3,c,d)pyrene	1.06E-03		1.4E+00	8.71E-07	3.73E-07		5.26E-07
benzo(g,h,i,c,d)perylene	1.06E-03		1.3E-01	8.71E-07	3.73E-07		5.00E-08
gamma-BHC	1.12E-03		1.80E+00	9.22E-07	3.95E-07		7.11E-07
aldrin	8.45E-06		1.70E+01	6.95E-09	2.98E-09		5.06E-08
DDE	1.21E-03			9.92E-07	4.25E-07		0.00E+00
alpha-chlordane	1.58E-03		1.30E+00	1.30E-06	5.57E-07		7.24E-07
gamma-chlordane	1.58E-03		1.30E+00	1.30E-06	5.57E-07		7.24E-07
aro-chlor-1242	2.00E-04			1.64E-07	7.05E-08		0.00E+00
aro-chlor-1254	7.55E-05			6.21E-08	2.66E-08		0.00E+00
TOTAL						1.09E-03	1.43E-04

Table J-8
 Lenz Oil Baseline Risk Assessment
 Residential/soil/ingestion/nonexcavated area (b)
 Adult

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		1.13E-08	4.84E-09	1.88E-07	0.00E+00
acetone	7.57E-02	1E-01		8.30E-08	3.56E-08	8.30E-07	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		3.84E-09	1.64E-09	3.84E-08	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		6.75E-09	2.89E-09	3.38E-07	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	8.00E-09	3.43E-09		3.12E-10
trichloroethane,1,1,1	2.58E-02	9E-02		2.83E-08	1.21E-08	3.14E-07	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		6.47E-09	2.77E-09	2.16E-05	0.00E+00
trichloroethene	4.01E-02		1.1E-02	4.39E-08	1.88E-08		2.07E-10
Benzene	5.99E-03		2.9E-02	6.56E-09	2.81E-09		8.16E-11
methyl,4-2-pentanone	6.12E-03			6.71E-09	2.87E-09		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	2.50E-08	1.07E-08	2.50E-06	5.46E-10
toluene	6.94E-03	2E-01		7.61E-09	3.26E-09	3.80E-08	0.00E+00
ethylbenzene	1.14E-02	1E-01		1.25E-08	5.35E-09	1.25E-07	0.00E+00
xylene (total)	2.15E-02	2E+00		2.36E-08	1.01E-08	1.18E-08	0.00E+00
naphthalene	8.20E-02	4E-02		8.99E-08	3.85E-08	2.25E-06	0.00E+00
methnaphthalene,2	7.70E-02			8.44E-08	3.62E-08		0.00E+00
acenaphthene	1.40E-01	6E-02		1.53E-07	6.58E-08	2.56E-06	0.00E+00
dibenzofuran	1.20E-01			1.32E-07	5.64E-08		0.00E+00
fluorene	2.21E-01	4E-02		2.42E-07	1.04E-07	6.05E-06	0.00E+00
phenanthrene	5.47E-01			5.99E-07	2.57E-07		0.00E+00
anthracene	2.75E-01	3E-01		3.01E-07	1.29E-07	1.00E-06	0.00E+00
fluoranthene	7.88E-01	4E-02		8.64E-07	3.70E-07	2.16E-05	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	7.21E-07	3.09E-07	2.40E-05	1.45E-07
butylbenzylphthalate	2.29E-01	2E-01		2.51E-07	1.08E-07	1.25E-06	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	5.14E-07	2.20E-07		1.85E-07
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	1.75E-07	7.51E-08	8.77E-06	1.05E-09
chrysene	4.34E-01		2.5E-02	4.76E-07	2.04E-07		5.10E-09
benzo(b)fluoranthene	4.54E-01		8.1E-01	4.98E-07	2.13E-07		1.73E-07
benzo(k)fluoranthene	4.35E-01		3.8E-01	4.77E-07	2.04E-07		7.82E-08
benzo(a)pyrene	4.54E-01		5.8E+00	4.98E-07	2.13E-07		1.24E-06
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	3.07E-07	1.32E-07		1.78E-07
benzo(g,h,i)perylene	2.88E-01		1.3E-01	3.16E-07	1.35E-07		1.73E-07
Gamma-BHC	1.30E-03	3E-04		1.42E-09	6.11E-10	4.75E-06	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	2.08E-09	8.92E-10	6.94E-05	1.52E-08
endosulfan I	5.20E-03			5.70E-09	2.44E-09		0.00E+00
DDE	2.10E-02		3.4E+01	2.30E-08	9.86E-09		3.35E-07
DDD	9.94E-03		2.4E+01	1.09E-08	4.67E-09		1.12E-07
DDT	1.28E-02	5E-04	3.4E-01	1.40E-08	6.01E-09	2.81E-05	2.04E-09
alpha chlordane	3.11E-03	6E-05	1.3E+00	3.41E-09	1.46E-09	5.68E-05	1.90E-09
gamma chlordane	2.94E-03	6E-05	1.3E+00	3.22E-09	1.38E-09	5.37E-05	1.80E-09
aro-chlor-1242	1.42E-01		7.7E+00	1.56E-07	6.67E-08		5.14E-07
aro-chlor-1254	6.02E-02		7.7E+00	6.60E-08	2.83E-08		2.18E-07
calcium	1.01E+05			1.11E-01	4.74E-02		0.00E+00
chromium	3.33E+01	1E+00		3.65E-05	1.56E-05	3.65E-05	0.00E+00
lead	3.53E+02			3.87E-04	1.66E-04		0.00E+00
magnesium	5.65E+04			6.19E-02	2.65E-02		0.00E+00
cadmium	1.03E+00	1E-03		1.13E-06	4.84E-07	1.13E-03	0.00E+00
Total-adult						1.47E-03	3.22E-06

Table J-8 (continued)
 Lenz Oil Baseline Risk Assessment
 Residential soil ingestion - child

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		2.63E-08	1.13E-08	4.39E-07	0.00E+00
acetone	7.57E-02	1E-01		1.94E-07	8.30E-08	1.94E-06	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		8.95E-09	3.84E-09	8.95E-08	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		1.58E-08	6.75E-09	7.88E-07	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	1.87E-08	8.00E-09		7.28E-10
trichloroethane,1,1,1	2.58E-02	9E-02		6.60E-08	2.83E-08	7.33E-07	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		1.51E-08	6.47E-09	5.03E-05	0.00E+00
trichloroethene	4.01E-02		1.1E-02	1.03E-07	4.39E-08		4.83E-10
Benzene	5.99E-03		2.9E-02	1.53E-08	6.56E-09		1.90E-10
methyl,4-2-pentanone	6.12E-03			1.56E-08	6.71E-09		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	5.83E-08	2.50E-08	5.83E-06	1.27E-09
toluene	6.94E-03	2E-01		1.77E-08	7.61E-09	8.87E-08	0.00E+00
ethylbenzene	1.14E-02	1E-01		2.92E-08	1.25E-08	2.92E-07	0.00E+00
xylene (total)	2.15E-02	2E+00		5.50E-08	2.36E-08	2.75E-08	0.00E+00
naphthalene	8.20E-02	4E-02		2.10E-07	8.99E-08	5.24E-06	0.00E+00
methnaphthalene,2	7.70E-02			1.97E-07	8.44E-08		0.00E+00
acenaphthene	1.40E-01	6E-02		3.58E-07	1.53E-07	5.97E-06	0.00E+00
dibenzofuran	1.20E-01			3.07E-07	1.32E-07		0.00E+00
fluorene	2.21E-01	4E-02		5.65E-07	2.42E-07	1.41E-05	0.00E+00
phenanthrene	5.47E-01			1.40E-06	5.99E-07		0.00E+00
anthracene	2.75E-01	3E-01		7.03E-07	3.01E-07	2.34E-06	0.00E+00
fluoranthene	7.88E-01	4E-02		2.01E-06	8.64E-07	5.04E-05	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	1.68E-06	7.21E-07	5.61E-05	3.39E-07
butylbenzylphthalate	2.29E-01	2E-01		5.86E-07	2.51E-07	2.93E-06	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	1.20E-06	5.14E-07		4.32E-07
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	4.09E-07	1.75E-07	2.05E-05	2.45E-09
chrysene	4.34E-01		2.5E-02	1.11E-06	4.76E-07		1.19E-08
benzo(b)fluoranthene	4.54E-01		8.1E-01	1.16E-06	4.98E-07		4.04E-07
benzo(k)fluoranthene	4.35E-01		3.8E-01	1.11E-06	4.77E-07		1.83E-07
benzo(a)pyrene	4.54E-01		5.8E+00	1.16E-06	4.98E-07		2.89E-06
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	7.16E-07	3.07E-07		4.14E-07
benzo(g,h,i)perylene	2.88E-01		1.3E-01	7.36E-07	3.16E-07		4.04E-08
Gamma-BHC	1.30E-03	3E-04		3.32E-09	1.42E-09	1.11E-05	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	4.86E-09	2.08E-09	1.62E-04	3.54E-08
endosulfan I	5.20E-03			1.33E-08	5.70E-09		0.00E+00
DDE	2.10E-02		3.4E+01	5.37E-08	2.30E-08		7.82E-07
DDD	9.94E-03		2.4E+01	2.54E-08	1.09E-08		2.61E-07
DDT	1.28E-02	5E-04	3.4E-01	3.27E-08	1.40E-08	6.55E-05	4.77E-09
alpha chlordane	3.11E-03	6E-05	1.3E+00	7.95E-09	3.41E-09	1.33E-04	4.43E-09
gamma chlordane	2.94E-03	6E-05	1.3E+00	7.52E-09	3.22E-09	1.25E-04	4.19E-09
arochlor-1242	1.42E-01		7.7E+00	3.63E-07	1.56E-07		1.20E-06
arochlor-1254	6.02E-02		7.7E+00	1.54E-07	6.60E-08		5.08E-07
calcium	6.01E+00			1.54E-05	6.59E-06		0.00E+00
chromium	4.33E+00	1E+00		1.11E-05	4.75E-06	1.11E-05	0.00E+00
lead	5.53E+00			1.41E-05	6.06E-06		0.00E+00
magnesium	9.65E+00			2.47E-05	1.06E-05		0.00E+00
cadmium	1.03E+00	1E-03		2.63E-06	1.13E-06	2.63E-03	0.00E+00
=====							
Total-child						3.36E-03	7.51E-06
Total Adult/Child						4.83E-03	1.07E-05

Table J-9

Larz Oil Baseline Risk Assessment

Residential/soil/dermal/nonexcavated area (B)

Adult

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF (mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		7.52E-08	3.22E-08	1.25E-06	0.00E+00
acetone	7.57E-02	1E-01		5.53E-07	2.37E-07	5.53E-06	0.00E+00
dichloroethane, 1,1	3.50E-03	1E-01		2.56E-08	1.10E-08	2.56E-07	0.00E+00
dichloroethane, 1,2	6.16E-03	2E-02		4.50E-08	1.93E-08	2.25E-06	0.00E+00
dichloroethane, 1,2	7.30E-03		9.1E-02	5.33E-08	2.29E-08		2.08E-09
trichloroethane, 1,1,1	2.58E-02	9E-02		1.88E-07	8.08E-08	2.09E-06	0.00E+00
dichloropropene, 1,3,T	5.90E-03	3E-04		4.31E-08	1.85E-08	1.44E-04	0.00E+00
trichloroethene	4.01E-02		1.1E-02	2.93E-07	1.26E-07		1.38E-09
Benzene	5.99E-03		2.9E-02	4.38E-08	1.88E-08		5.44E-10
methyl 4-2-pentanone	6.12E-03			4.47E-08	1.92E-08		0.00E+00
tetrachloroethene	2.28E-03	1E-02	5.1E-02	1.67E-08	7.14E-09	1.67E-06	3.64E-10
toluene	6.94E-03	2E-01		5.07E-08	2.17E-08	2.53E-07	0.00E+00
ethylbenzene	1.14E-02	1E-01		8.33E-08	3.57E-08	8.33E-07	0.00E+00
xylene (total)	2.15E-02	2E+00		1.57E-07	6.73E-08	7.85E-08	0.00E+00
naphthalene	8.20E-02	4E-02		2.40E-07	1.03E-07	5.99E-06	0.00E+00
methnaphthalene, 2	7.70E-02			2.25E-07	9.64E-08		0.00E+00
acenaphthene	1.40E-01	6E-02		4.09E-07	1.75E-07	6.82E-06	0.00E+00
dibenzofuran	1.20E-01			3.51E-07	1.50E-07		0.00E+00
fluorene	2.21E-01	4E-02		6.46E-07	2.77E-07	1.61E-05	0.00E+00
phenanthrene	5.47E-01			1.60E-06	6.85E-07		0.00E+00
anthracene	2.75E-01	3E-01		8.03E-07	3.44E-07	2.68E-06	0.00E+00
fluoranthene	7.88E-01	4E-02		2.30E-06	9.87E-07	5.76E-05	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	1.92E-06	8.24E-07	6.41E-05	3.87E-07
butylbenzylphthalate	2.29E-01	2E-01		6.69E-07	2.87E-07	3.35E-06	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	1.37E-06	5.87E-07		4.94E-07
bis(2-ethylhexyl)phthalate	1.60E-01	2E-02	1.4E-02	4.67E-07	2.00E-07	2.34E-05	2.80E-09
chrysene	4.34E-01		2.5E-02	1.27E-06	5.43E-07		1.36E-08
benzo(b)fluoranthene	4.54E-01		8.1E-01	1.33E-06	5.68E-07		4.62E-07
benzo(k)fluoranthene	4.35E-01		3.8E-01	1.27E-06	5.45E-07		2.09E-07
benzo(a)pyrene	4.54E-01		5.8E+00	1.33E-06	5.68E-07		3.30E-06
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	8.18E-07	3.51E-07		4.73E-07
benzo(g,h,i)perylene	2.88E-01		1.3E-01	8.41E-07	3.61E-07		4.62E-08
Gamma-BHC	1.30E-03	3E-04		3.80E-09	1.63E-09	1.27E-05	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	5.55E-09	2.38E-09	1.85E-04	4.04E-07
endosulfan I	5.20E-03			1.52E-08	6.51E-09		0.00E+00
DDE	9.94E-03		3.4E+01	2.90E-08	1.24E-08		4.23E-07
DDD	1.28E-02		2.4E+01	3.74E-08	1.60E-08		3.85E-07
DDT	3.11E-03	5E-04	3.4E-01	9.09E-09	3.89E-09	1.82E-05	1.32E-09
alpha-chlordane	3.11E-03	6E-05	1.3E+00	9.09E-09	3.89E-09	1.51E-04	5.06E-09
gamma-chlordane	2.94E-03	6E-05	1.3E+00	8.59E-09	3.68E-09	1.43E-04	4.79E-09
arochlor-1242	1.42E-01		7.7E+00	4.15E-07	1.78E-07		1.37E-06
arochlor-1254	6.02E-02		7.7E+00	1.76E-07	7.54E-08		5.80E-07
calcium	1.01E+05			2.95E-02	1.26E-02		0.00E+00
chromium	3.33E+01	1E+00		9.73E-06	4.17E-06	9.73E-06	0.00E+00
lead	3.53E+02			1.03E-04	4.42E-05		0.00E+00
magnesium	5.65E+04			1.65E-02	7.07E-03		0.00E+00
cadmium	1.03E+00	1E-03		3.01E-07	1.29E-07	3.01E-04	0.00E+00
Total-adult						1.16E-03	8.20E-06

Table J-9 (continued)
 Lenz Oil Baseline Risk Assessment
 Residential soil dermal - children

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		3.45E-08	1.48E-08	5.75E-07	0.00E+00
acetone	7.57E-02	1E-01		2.54E-07	1.09E-07	2.54E-06	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		1.17E-08	5.02E-09	1.17E-07	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		2.06E-08	8.84E-09	1.03E-06	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	2.45E-08	1.05E-08		9.54E-10
trichloroethane,1,1,1	2.58E-02	9E-02		8.64E-08	3.70E-08	9.60E-07	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		1.98E-08	8.47E-09	6.59E-05	0.00E+00
trichloroethene	4.01E-02		1.1E-02	1.34E-07	5.76E-08		6.33E-10
Benzene	5.99E-03		2.9E-02	2.01E-08	8.60E-09		2.49E-10
methyl,4-2-pentanone	6.12E-03			2.05E-08	8.79E-09		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	7.64E-08	3.27E-08	7.64E-06	1.67E-09
toluene	6.94E-03	2E-01		2.32E-08	9.96E-09	1.16E-07	0.00E+00
ethylbenzene	1.14E-02	1E-01		3.82E-08	1.64E-08	3.82E-07	0.00E+00
xylenes (total)	2.15E-02	2E+00		7.20E-08	3.09E-08	3.60E-08	0.00E+00
naphthalene	8.20E-02	4E-02		1.10E-07	4.71E-08	2.75E-06	0.00E+00
methnaphthalene,2	7.70E-02			1.03E-07	4.42E-08		0.00E+00
acenaphthene	1.40E-01	6E-02		1.88E-07	8.04E-08	3.13E-06	0.00E+00
dibenzofuran	1.20E-01			1.61E-07	6.89E-08		0.00E+00
fluorene	2.21E-01	4E-02		2.96E-07	1.27E-07	7.40E-06	0.00E+00
phenanthrene	5.47E-01			7.33E-07	3.14E-07		0.00E+00
anthracene	2.75E-01	3E-01		3.68E-07	1.58E-07	1.23E-06	0.00E+00
fluoranthene	7.88E-01	4E-02		1.06E-06	4.53E-07	2.64E-05	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	8.82E-07	3.78E-07	2.94E-05	1.78E-07
butylbenzylphthalate	2.29E-01	2E-01		3.07E-07	1.32E-07	1.53E-06	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	6.28E-07	2.69E-07		2.26E-07
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	2.14E-07	9.19E-08	1.07E-05	1.29E-09
chrysene	4.34E-01		2.5E-02	5.82E-07	2.49E-07		6.23E-09
benzo(b)fluoranthene	4.54E-01		8.1E-01	6.08E-07	2.61E-07		2.12E-07
benzo(k)fluoranthene	4.35E-01		3.8E-01	5.83E-07	2.50E-07		9.57E-08
benzo(a)pyrene	4.54E-01		5.8E+00	6.08E-07	2.61E-07		1.51E-06
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	3.75E-07	1.61E-07		2.17E-07
benzo(g,h,i)perylene	2.88E-01		1.3E-01	3.86E-07	1.65E-07		2.12E-08
Gamma-BHC	1.30E-03	3E-04		1.74E-09	7.47E-10	5.81E-06	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	2.55E-09	1.09E-09	8.49E-05	1.85E-08
endosulfan I	5.20E-03			6.97E-09	2.99E-09		0.00E+00
DDE	2.10E-02		3.4E+01	2.81E-08	1.21E-08		4.10E-07
DDD	9.94E-03		2.4E+01	1.33E-08	5.71E-09		1.37E-07
DDT	1.28E-02	5E-04	3.4E-01	1.72E-08	7.35E-09	3.43E-05	2.50E-09
alpha chlordane	3.11E-03	6E-05	1.3E+00	4.17E-09	1.79E-09	6.95E-05	2.32E-09
gamma chlordane	2.94E-03	6E-05	1.3E+00	3.94E-09	1.69E-09	6.57E-05	2.19E-09
aro chlor-1242	1.42E-01		7.7E+00	1.90E-07	8.15E-08		6.28E-07
aro chlor-1254	6.02E-02		7.7E+00	8.07E-08	3.46E-08		2.66E-07
calcium	1.01E+05			1.35E-02	5.80E-03		0.00E+00
chromium	3.33E+01	1E+00		4.46E-06	1.91E-06	4.46E-06	0.00E+00
lead	3.53E+02			4.73E-05	2.03E-05		0.00E+00
magnesium	5.65E+04			7.57E-03	3.24E-03		0.00E+00
cadmium	1.03E+00	1E-03		1.38E-07	5.91E-08	1.38E-04	0.00E+00
Total-child						5.64E-04	3.94E-06
TOTAL-adult/child						1.72E-03	1.21E-05

Table J-10

Lenz Oil Service Site

Inhalation/residential/adults/area B

dispersion model

Chemical	Conc. (mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.82E-03			1.59E-03	6.83E-04		0.00E+00
acetone	5.43E-02			1.49E-02	6.38E-03		0.00E+00
dichloroethane,1,1	8.45E-03			2.32E-03	9.92E-04		0.00E+00
dichloroethane,1,2	3.01E-03			8.25E-04	3.53E-04		0.00E+00
dichloroethane,1,2	5.38E-03		9.10E-02	1.47E-03	6.32E-04		5.75E-05
trichloroethane,1,1,1	1.26E-02			3.45E-03	1.48E-03		0.00E+00
dichloropropene,t-1,3	1.30E-03	6.00E-03		3.56E-04	1.53E-04	5.94E-02	0.00E+00
trichloroethene	3.48E-02		1.7E-02	9.53E-03	4.09E-03		6.95E-05
tetrachloroethene	9.93E-02		1.8E-03	2.72E-02	1.17E-02		2.10E-05
toluene	6.84E-03	4E-01		1.87E-03	8.03E-04	4.68E-03	0.00E+00
ethylbenzene	4.10E-03	3E-01		1.12E-03	4.81E-04	3.74E-03	0.00E+00
xylene(s total)	9.07E-03			2.48E-03	1.06E-03		0.00E+00
naphthalene	4.00E-02			1.10E-02	4.70E-03		0.00E+00
fluorene	2.31E-03			6.33E-04	2.71E-04		0.00E+00
anthracene	1.25E-04			3.42E-05	1.47E-05		0.00E+00
fluoranthene	1.16E-04			3.18E-05	1.36E-05		0.00E+00
pyrene	5.35E-07		4.9E-01	1.47E-07	6.28E-08		3.10E-08
dichlorobenzidine,3,3	1.00E-06			2.74E-07	1.17E-07		0.00E+00
butylbenzylphthalate	1.16E-03			3.17E-04	1.36E-04		0.00E+00
benzo(a)anthracene	1.09E-03		8.8E-01	2.98E-04	1.28E-04		1.13E-04
bis-(2-ethylhexyl)phthalate	1.06E-03			2.90E-04	1.24E-04		0.00E+00
chrysene	7.33E-06		2.7E-02	2.01E-06	8.61E-07		2.32E-08
benzo(b)fluoranthene	4.31E-01		8.5E-01	1.18E-01	5.06E-02		4.32E-02
benzo(k)fluoranthene	6.71E-02		4.0E-01	1.84E-02	7.88E-03		3.18E-03
benzo(a)pyrene	1.32E-04		6.1E+00	3.62E-05	1.55E-05		9.45E-05
indeno(1,2,3,c,d)pyrene	1.06E-03		1.4E+00	2.90E-04	1.24E-04		1.75E-04
benzo(g,h,i,c,d)perylene	1.06E-03		1.3E-01	2.90E-04	1.24E-04		1.67E-05
gamma-BHC	1.12E-03		1.80E+00	3.07E-04	1.32E-04		2.37E-04
aldrin	8.45E-06		1.70E+01	2.32E-06	9.92E-07		1.69E-05
DDE	1.21E-03			3.31E-04	1.42E-04		0.00E+00
alpha-chlordane	1.58E-03		1.30E+00	4.33E-04	1.86E-04		2.41E-04
gamma-chlordane	1.58E-03		1.30E+00	4.33E-04	1.86E-04		2.41E-04
arochlor-1242	2.00E-04			5.48E-05	2.35E-05		0.00E+00
arochlor-1254	7.55E-05			2.07E-05	8.86E-06		0.00E+00
TOTAL						6.78E-02	4.77E-02

Table J-11
 Lenz Oil Baseline Risk Assessment
 Residential/inhalation/particulates
 Adults

Chemical	Conc. (mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Area A-screening using PEF							
cadmium	1.51E-07		6.1E+00	4.14E-08	1.77E-08		1.08E-07
chromium	6.32E-06			1.73E-06	7.42E-07		0.00E+00
lead	6.09E-05			1.67E-05	7.15E-06		0.00E+00
zinc	4.01E-05			1.10E-05	4.71E-06		0.00E+00
methylene chloride	6.60E-09			1.81E-09	7.75E-10		0.00E+00
acetone	0.00E+00			0.00E+00	0.00E+00		0.00E+00
dichloroethane,1,1	6.10E-10			1.67E-10	7.16E-11		0.00E+00
trichloroethane,1,1,1	1.75E-09			4.79E-10	2.05E-10		0.00E+00
trichloroethene	1.02E-09		1.70E-02	2.79E-10	1.20E-10		2.04E-12
tetrachloroethene	1.37E-09		1.80E-03	3.75E-10	1.61E-10		2.90E-13
toluene	3.78E-09	4.00E-01		1.04E-09	4.44E-10	2.59E-09	0.00E+00
ethylbenzene	2.66E-09	3.00E-01		7.29E-10	3.12E-10	2.43E-09	0.00E+00
xylene (total)	1.27E-09			3.48E-10	1.49E-10		0.00E+00
dichlorobenzene,1,2	1.71E-08			4.68E-09	2.01E-09		0.00E+00
naphthalene	7.32E-09			2.01E-09	8.59E-10		0.00E+00
acenaphthene	3.00E-08			8.22E-09	3.52E-09		0.00E+00
fluorene	3.45E-08			9.45E-09	4.05E-09		0.00E+00
anthracene	4.41E-08			1.21E-08	5.18E-09		0.00E+00
fluoranthene	1.72E-07			4.71E-08	2.02E-08		0.00E+00
pyrene	1.56E-07		4.94E-01	4.27E-08	1.83E-08		9.05E-09
benzo(a)anthracene	7.23E-08		8.84E-01	1.98E-08	8.49E-09		7.50E-09
bis(2-ethylhex)phthalate	3.41E-08			9.34E-09	4.00E-09		0.00E+00
chrysene	7.70E-08		2.70E-02	2.11E-08	9.04E-09		2.44E-10
benzo(b)fluoranthene	7.98E-08		8.54E-01	2.19E-08	9.37E-09		8.00E-09
benzo(k)fluoranthene	4.91E-08		4.03E-01	1.35E-08	5.77E-09		2.32E-09
benzo(a)pyrene	6.13E-08		6.10E+00	1.68E-08	7.20E-09		4.39E-08
indeno(1,2,3c,d)perylene	4.63E-08		1.41E+00	1.27E-08	5.44E-09		7.67E-09
arochlor 1242	5.06E-08			1.39E-08	5.94E-09		0.00E+00
arochlor 1260	1.39E-08			3.81E-09	1.63E-09		0.00E+00
Total						5.02E-09	1.87E-07

Table J-11 – Lenz Oil Services Baseline Risk Assessment (continued)

Area B – screening using PEF							
Chemical	Conc. (mg/m ³)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
cadmium	2.51E-06		6.1E+00	6.88E-07	2.95E-07		1.80E-07
chromium	8.12E-07			2.22E-07	9.53E-08		0.00E+00
lead	8.61E-06			2.36E-06	1.01E-06		0.00E+00
zinc	0.00E+00			0.00E+00	0.00E+00		0.00E+00
methylene chloride	2.51E-10			6.88E-11	2.95E-11		0.00E+00
acetone	1.85E-09			5.07E-10	2.17E-10		0.00E+00
dichloroethane,1,1	8.54E-10			2.34E-10	1.00E-10		0.00E+00
dichloroethane,1,2	1.50E-10			4.11E-11	1.76E-11		0.00E+00
dichloroethane 1,2	1.78E-10		9.10E-02	4.88E-11	2.09E-11		1.90E-12
trichloroethane,1,1,1	6.29E-10			1.72E-10	7.39E-11		0.00E+00
dichlorpropene,1,3 t	1.44E-10	6.00E-03		3.95E-11	1.69E-11	6.58E-09	0.00E+00
trichloroethene	9.78E-10		1.70E-02	2.68E-10	1.15E-10		1.95E-12
tetrachloroethene	5.56E-10		1.80E-03	1.52E-10	6.53E-11		1.18E-13
toluene	1.69E-10	4.00E-01		4.63E-11	1.98E-11	1.16E-10	0.00E+00
TCA 1,1,2,2	0.00E+00		2.00E-01	0.00E+00	0.00E+00		0.00E+00
ethylbenzene	2.78E-10	3.00E-01		7.62E-11	3.26E-11	2.54E-10	0.00E+00
xylenes (total)	5.24E-10			1.44E-10	6.15E-11		0.00E+00
isophorone	0.00E+00			0.00E+00	0.00E+00		0.00E+00
dimethylphenol 2,4	0.00E+00			0.00E+00	0.00E+00		0.00E+00
naphthalene	2.00E-09			5.48E-10	2.35E-10		0.00E+00
fluorene	5.39E-09			1.48E-09	6.33E-10		0.00E+00
anthracene	6.71E-09			1.84E-09	7.88E-10		0.00E+00
fluoranthene	1.92E-08			5.26E-09	2.25E-09		0.00E+00
pyrene	1.60E-08		4.94E-01	4.38E-09	1.88E-09		9.28E-10
butylbenzylphthalate	5.59E-09			1.53E-09	6.56E-10		0.00E+00
dichlorobenzidine,3,3	0.00E+00			0.00E+00	0.00E+00		0.00E+00
benzo(a)anthracene	1.14E-08		8.84E-01	3.12E-09	1.34E-09		1.18E-09
bis(2-ethoxy)phthalate	3.90E-09			1.07E-09	4.58E-10		0.00E+00
chrysene	1.06E-08		2.70E-02	2.90E-09	1.24E-09		3.36E-11
di-n-octyl phthalate	0.00E+00			0.00E+00	0.00E+00		0.00E+00
benzo(b)fluoranthene	1.11E-08		8.54E-01	3.04E-09	1.30E-09		1.11E-09
benzo(k)fluoranthene	1.06E-08		4.03E-01	2.90E-09	1.24E-09		5.02E-10
benzo(a)pyrene	1.11E-08		6.10E+00	3.04E-09	1.30E-09		7.95E-11
indeno(1,2,3c,d)perylene	6.83E-09		1.41E+00	1.87E-09	8.02E-10		1.13E-09
benzo(ghi)perylene	7.02E-09		1.34E-01	1.92E-09	8.24E-10		1.10E-10
gamma-BHC	3.17E-11			8.68E-12	3.72E-12		0.00E+00
aldrin	4.63E-11		1.70E+01	1.27E-11	5.44E-12		9.24E-11
DDE	5.12E-10			1.40E-10	6.01E-11		0.00E+00
alpha chlordane	7.59E-11		1.30E+00	2.08E-11	8.91E-12		1.16E-11
gamma chlordane	7.17E-11		1.30E+00	1.96E-11	8.42E-12		1.09E-11
aro-chlor 1242	3.46E-09			9.48E-10	4.06E-10		0.00E+00
aro-chlor 1254	1.47E-09			4.03E-10	1.73E-10		0.00E+00
aro-chlor 1260	0.00E+00			0.00E+00	0.00E+00		0.00E+00
TOTAL						6.94E-09	1.81E-06

Table J-12
Lenz Oil Baseline Risk Assessment
residential/soil/ingestion/excavated area (A)

Adult

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.41E-02	6E-02		5.93E-08	2.54E-08	9.88E-07	0.00E+00
dichloroethane,1,1	5.00E-03	1E-01		5.48E-09	2.35E-09	5.48E-08	0.00E+00
trichloroethane,1,1,1	1.46E-02	9E-02		1.60E-08	6.86E-09	1.78E-07	0.00E+00
trichloroethane	8.35E-03		1.1E-02	9.15E-09	3.92E-09		4.31E-11
tetrachloroethane	1.12E-02	1E-02	5.1E-02	1.23E-08	5.26E-09	1.23E-08	2.88E-10
Toluene	3.10E-02	2E-01		3.40E-08	1.46E-08	1.70E-07	0.00E+00
Ethylbenzene	2.18E-02	1E-01		2.39E-08	1.02E-08	2.39E-07	0.00E+00
Xylenes (total)	1.13E-01	2E+00		1.24E-07	5.31E-08	6.19E-08	0.00E+00
Dichlorobenzene,1,2,	1.40E-01	9E-02		1.53E-07	6.58E-08	1.70E-08	0.00E+00
naphthalene	6.00E-02	4E-02		6.58E-08	2.82E-08	1.64E-08	0.00E+00
Meth.Naph.2	6.77E-01			7.42E-07	3.18E-07		0.00E+00
Acenaphthene	2.48E-01	6E-02		2.70E-07	1.16E-07	4.49E-08	0.00E+00
dibenzofuran	1.70E-01			1.86E-07	7.98E-08		0.00E+00
Fluorene	2.83E-01	4E-02		3.10E-07	1.33E-07	7.75E-08	0.00E+00
Phenanthrene	1.35E+00			1.48E-08	6.34E-07		0.00E+00
Anthracene	3.62E-01	3E-01		3.97E-07	1.70E-07	1.32E-06	0.00E+00
Fluoranthene	1.41E+00	4E-02		1.55E-08	6.62E-07	3.86E-05	0.00E+00
Pyrene	1.28E+00	3E-02	4.7E-01	1.40E-08	6.01E-07	4.68E-05	2.83E-07
benzo(a)anthracene	5.93E-01		8.4E-01	6.50E-07	2.79E-07		2.34E-07
Bis(2ethoxy)phthalate	2.80E-01	2E-02	1.4E-02	3.07E-07	1.32E-07	1.53E-05	1.84E-09
chrysene	6.31E-01		2.5E-02	6.92E-07	2.98E-07		7.41E-09
benzo(b)fluoranthene	6.54E-01		8.1E-01	7.17E-07	3.07E-07		2.49E-07
benzo(k)fluoranthene	4.03E-01		3.8E-01	4.42E-07	1.89E-07		7.25E-08
benzo(a)pyrene	5.03E-01		5.8E+00	5.51E-07	2.36E-07		1.37E-08
indeno(1,2,3,c,d)pyrene	3.80E-01		1.4E+00	4.16E-07	1.78E-07		2.41E-07
Benzo(g,h,i)perylene	3.61E-01		1.3E-01	3.96E-07	1.70E-07		2.17E-08
Arochlor-1242	4.15E-01		7.7E+00	4.55E-07	1.95E-07		1.50E-08
Arochlor-1260	1.14E-01		7.7E+00	1.25E-07	5.35E-08		4.12E-07
Beryllium	1.10E+00	5E-03		1.21E-08	5.17E-07	2.41E-04	0.00E+00
Cadmium	1.24E+00	1E-03		1.36E-08	5.82E-07	1.36E-03	0.00E+00
Calcium	1.06E+05			1.16E-01	4.98E-02		0.00E+00
chromium (total)	5.18E+01	1E+00		5.68E-05	2.43E-05	5.68E-05	0.00E+00
lead	4.99E+02			5.47E-04	2.34E-04		0.00E+00
zinc	3.29E+02	2.00E-01		3.61E-04	1.55E-04	1.80E-03	0.00E+00
Total-adult						3.58E-03	4.39E-08

Residential soil ingestion-child

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.41E-02	6E-02		1.38E-07	5.93E-08	2.31E-08	0.00E+00
dichloroethane,1,1	5.00E-03	1E-01		1.28E-08	5.48E-09	1.28E-07	0.00E+00
trichloroethane,1,1,1	1.46E-02	9E-02		3.73E-08	1.60E-08	4.15E-07	0.00E+00
trichloroethane	8.50E-03		1.1E-02	2.17E-08	9.32E-09		1.02E-10
tetrachloroethane	1.12E-02	1E-02	5.1E-02	2.86E-08	1.23E-08	2.86E-08	6.26E-10
Toluene	3.10E-02	2E-01		7.93E-08	3.40E-08	3.98E-07	0.00E+00
Ethylbenzene	2.18E-02	1E-01		5.57E-08	2.39E-08	5.57E-07	0.00E+00
Xylenes (total)	1.13E-01	2E+00		2.89E-07	1.24E-07	1.44E-07	0.00E+00
Dichlorobenzene,1,2,	1.40E-01	9E-02		3.58E-07	1.53E-07	3.98E-08	0.00E+00
naphthalene	6.00E-02	4E-02		1.53E-07	6.58E-08	3.84E-08	0.00E+00
Meth.Naph.2	6.77E-01			1.73E-08	7.42E-07		0.00E+00
Acenaphthene	2.48E-01	6E-02		6.29E-07	2.70E-07	1.05E-05	0.00E+00
dibenzofuran	1.70E-01			4.35E-07	1.86E-07		0.00E+00
Fluorene	2.83E-01	4E-02		7.24E-07	3.10E-07	1.81E-05	0.00E+00
Phenanthrene	1.35E+00			3.45E-08	1.48E-08		0.00E+00
Anthracene	3.62E-01	3E-01		9.26E-07	3.97E-07	3.09E-06	0.00E+00
Fluoranthene	1.41E+00	4E-02		3.61E-08	1.55E-08	9.01E-05	0.00E+00
Pyrene	1.28E+00	3E-02	4.7E-01	3.27E-08	1.40E-08	1.09E-04	6.59E-07
benzo(a)anthracene	5.93E-01		8.4E-01	1.52E-08	6.50E-07		5.46E-07
Bis(2ethoxy)phthalate	2.80E-01	2E-02	1.4E-02	7.16E-07	3.07E-07	3.58E-05	4.30E-09
chrysene	6.31E-01		2.5E-02	1.61E-08	6.92E-07		1.73E-08
benzo(b)fluoranthene	6.54E-01		8.1E-01	1.67E-08	7.17E-07		5.82E-07
benzo(k)fluoranthene	4.03E-01		3.8E-01	1.03E-08	4.42E-07		1.89E-07
benzo(a)pyrene	5.03E-01		5.8E+00	1.29E-08	5.51E-07		3.20E-08
indeno(1,2,3,c,d)pyrene	3.80E-01		1.4E+00	9.72E-07	4.16E-07		5.62E-07
Benzo(g,h,i)perylene	3.61E-01		1.3E-01	9.23E-07	3.96E-07		5.06E-08
Arochlor-1242	4.15E-01		7.7E+00	1.06E-08	4.55E-07		3.50E-08
Arochlor-1260	1.14E-01		7.7E+00	2.92E-07	1.25E-07		9.62E-07
Beryllium	1.10E+00	5E-03		2.81E-08	1.21E-08	5.63E-04	0.00E+00
Cadmium	1.24E+00	1E-03		3.17E-08	1.36E-08	3.17E-03	0.00E+00
Calcium	1.06E+05			2.71E-01	1.16E-01		0.00E+00
chromium (total)	5.18E+01	1E+00		1.32E-04	5.68E-05	1.32E-04	0.00E+00
lead	4.99E+02			1.28E-03	5.47E-04		0.00E+00
zinc	3.29E+02	2.00E-01		8.41E-04	3.61E-04	4.21E-03	0.00E+00
Total-child						8.35E-03	1.03E-05
Total Adult/Child						1.19E-02	1.46E-05

Table J-13
Lenz Oil Baseline Risk Assessment
Residential/soil/dermal contact/excavated Area (A)

Adult

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.44E-01	6E-02		3.97E-06	1.70E-06	6.62E-05	0.00E+00
dichloroethane,1,1	5.00E-03	1E-01		3.65E-08	1.57E-08	3.65E-07	0.00E+00
trichloroethane,1,1,1	1.46E-02	9E-02		1.07E-07	4.57E-08	1.18E-06	0.00E+00
trichloroethene	8.35E-03		1.1E-02	6.10E-08	2.61E-08		2.88E-10
tetrachloroethene	1.12E-02	1E-02	5.1E-02	8.18E-08	3.51E-08	8.18E-06	1.79E-09
Toluene	3.10E-02	2E-01		2.26E-07	9.70E-08	1.13E-06	0.00E+00
Ethylbenzene	2.18E-02	1E-01		1.59E-07	6.82E-08	1.59E-06	0.00E+00
Xylenes (total)	1.13E-01	2E+00		8.25E-07	3.54E-07	4.13E-07	0.00E+00
Dichlorobenzene,1,2,	1.40E-01	9E-02		4.09E-07	1.75E-07	4.54E-06	0.00E+00
naphthalene	6.00E-02	4E-02		1.75E-07	7.51E-08	4.38E-06	0.00E+00
Meth.Naph.2	6.77E-01			1.98E-06	8.46E-07		0.00E+00
Acenaphthene	2.46E-01	6E-02		7.19E-07	3.08E-07	1.20E-05	0.00E+00
dibenzofuran	1.70E-01			4.97E-07	2.13E-07		0.00E+00
Fluorene	2.83E-01	4E-02		8.27E-07	3.54E-07	2.07E-05	0.00E+00
Phenanthrene	1.35E+00			3.94E-06	1.69E-06		0.00E+00
Anthracene	3.62E-01	3E-01		1.06E-06	4.53E-07	3.53E-06	0.00E+00
Fluoranthene	1.41E+00	4E-02		4.12E-06	1.77E-06	1.03E-04	0.00E+00
Pyrene	1.28E+00	3E-02	4.7E-01	3.74E-06	1.60E-06	1.25E-04	7.53E-07
benzo(a)anthracene	5.93E-01		8.4E-01	1.73E-06	7.43E-07		6.24E-07
Bis(2ethnhex)phthalate	2.80E-01	2E-02	1.4E-02	8.18E-07	3.51E-07	4.09E-05	4.91E-09
chrysene	6.31E-01		2.5E-02	1.84E-06	7.90E-07		1.98E-08
benzo(b)fluoranthene	6.54E-01		8.1E-01	1.91E-06	8.19E-07		6.65E-07
benzo(k)fluoranthene	4.03E-01		3.8E-01	1.18E-06	5.05E-07		1.93E-07
benzo(a)pyrene	5.03E-01		5.8E+00	1.47E-06	6.30E-07		3.65E-06
indeno(1,2,3,c,d)pyrene	3.80E-01		1.4E+00	1.11E-06	4.76E-07		6.42E-07
Benzo(g,h,i)perylene	3.61E-01		1.3E-01	1.05E-06	4.52E-07		5.79E-08
Arochlor-1242	4.15E-01		7.7E+00	1.21E-06	5.20E-07		4.00E-06
Arochlor-1260	1.14E-01		7.7E+00	3.33E-07	1.43E-07		1.10E-06
Beryllium	1.10E+00	5E-03		3.21E-07	1.38E-07	6.43E-05	0.00E+00
Cadmium	1.24E+00	1E-03		3.62E-07	1.55E-07	3.62E-04	0.00E+00
Calcium	1.06E+05			3.10E-02	1.33E-02		0.00E+00
chromium (total)	5.18E+01	1E+00		1.51E-05	6.49E-06	1.51E-05	0.00E+00
lead	4.99E+02			1.46E-04	6.25E-05		0.00E+00
zinc	3.29E+02	2E-01		9.61E-05	4.12E-05	4.81E-04	0.00E+00
TOTAL						1.32E-03	1.17E-05

Residential soil dermal-children

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.41E-02	6E-02		1.81E-07	7.77E-08	3.02E-06	0.00E+00
dichloroethane,1,1	5.00E-03	1E-01		1.67E-08	7.18E-09	1.67E-07	0.00E+00
trichloroethane,1,1,1	1.46E-02	9E-02		4.89E-08	2.10E-08	5.43E-07	0.00E+00
trichloroethene	5.35E+00		1.1E-02	1.79E-05	7.68E-06		8.45E-08
tetrachloroethene	1.12E-02	1E-02	5.1E-02	3.75E-08	1.61E-08	3.75E-06	8.20E-10
Toluene	3.10E-02	2E-01		1.04E-07	4.45E-08	5.19E-07	0.00E+00
Ethylbenzene	2.18E-02	1E-01		7.30E-08	3.13E-08	7.30E-07	0.00E+00
Xylenes (total)	1.13E-01	2E+00		3.79E-07	1.62E-07	1.89E-07	0.00E+00
Dichlorobenzene,1,2,	1.40E-01	9E-02		1.88E-07	8.04E-08	2.08E-06	0.00E+00
naphthalene	6.00E-02	4E-02		8.04E-08	3.45E-08	2.01E-06	0.00E+00
Meth.Naph.2	6.77E-01			9.07E-07	3.89E-07		0.00E+00
Acenaphthene	2.46E-01	6E-02		3.30E-07	1.41E-07	5.49E-06	0.00E+00
dibenzofuran	1.70E-01			2.28E-07	9.76E-08		0.00E+00
Fluorene	2.83E-01	4E-02		3.79E-07	1.63E-07	9.48E-06	0.00E+00
Phenanthrene	1.35E+00			1.81E-06	7.75E-07		0.00E+00
Anthracene	3.62E-01	3E-01		4.85E-07	2.08E-07	1.62E-06	0.00E+00
Fluoranthene	1.41E+00	4E-02		1.89E-06	8.10E-07	4.72E-05	0.00E+00
Pyrene	1.28E+00	3E-02	4.7E-01	1.72E-06	7.35E-07	5.72E-05	3.45E-07
benzo(a)anthracene	5.93E-01		8.4E-01	7.95E-07	3.41E-07		2.86E-07
Bis(2ethnhex)phthalate	2.80E-01	2E-02	1.4E-02	3.75E-07	1.61E-07	1.88E-05	2.25E-09
chrysene	6.31E-01		2.5E-02	8.45E-07	3.62E-07		9.06E-09
benzo(b)fluoranthene	6.54E-01		8.1E-01	8.76E-07	3.76E-07		3.05E-07
benzo(k)fluoranthene	4.03E-01		3.8E-01	5.40E-07	2.31E-07		8.86E-08
benzo(a)pyrene	5.03E-01		5.8E+00	6.74E-07	2.89E-07		1.68E-06
indeno(1,2,3,c,d)pyrene	3.80E-01		1.4E+00	5.09E-07	2.18E-07		2.95E-07
Benzo(g,h,i)perylene	3.61E-01		1.3E-01	4.84E-07	2.07E-07		2.65E-08
Arochlor-1242	4.15E-01		7.7E+00	5.56E-07	2.38E-07		1.84E-06
Arochlor-1260	1.14E-01		7.7E+00	1.53E-07	6.55E-08		5.04E-07
Beryllium	1.10E+00	5E-03		1.47E-07	6.32E-08	2.95E-05	0.00E+00
Cadmium	1.24E+00	1E-03		1.66E-07	7.12E-08	1.66E-04	0.00E+00
Calcium	1.06E+05			1.42E-02	6.09E-03		0.00E+00
chromium (total)	5.18E+01	1E+00		6.94E-06	2.97E-06	6.94E-06	0.00E+00
lead	4.99E+02			6.69E-05	2.87E-05		0.00E+00
zinc	3.29E+02	2E-01		4.41E-05	1.89E-05	2.20E-04	0.00E+00
Total-child						5.78E-04	5.48E-06
Total-adult/child						1.89E-03	1.72E-05

Table J-14

Lenz Oil Service Baseline Risk Assessment
 Inhalation/residential/adults/area A
 dispersion model

Chemical	Conc. (mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	6.63E-03			1.82E-03	7.78E-04		0.00E+00
acetone	0.00E+00			0.00E+00	0.00E+00		0.00E+00
carbon disulfide	1.87E-03	3.00E-03		5.12E-04	2.20E-04	1.71E-01	0.00E+00
dichloroethane, 1,1	4.74E-04		1.2E+00	1.30E-04	5.57E-05		6.68E-05
chloroform	9.43E-04		8.10E-02	2.58E-04	1.11E-04		8.97E-06
trichloroethane, 1,1,1	1.39E-03			3.81E-04	1.63E-04		0.00E+00
trichloroethene	6.52E-03		1.7E-02	1.79E-03	7.66E-04		1.30E-05
tetrachloroethene	7.95E-03		1.8E-03	2.18E-03	9.33E-04		1.68E-06
toluene	2.86E-02	4E-01		7.84E-03	3.36E-03	1.96E-02	0.00E+00
ethylbenzene	1.45E-02	3E-01		3.97E-03	1.70E-03	1.32E-02	0.00E+00
xylene(s) (total)	5.84E-01			1.60E-01	6.86E-02		0.00E+00
phenol	2.70E-02			7.40E-03	3.17E-03		0.00E+00
dichlorobenzene, 1,2	5.52E-03			1.51E-03	6.48E-04		0.00E+00
naphthalene	8.73E-03			2.39E-03	1.03E-03		0.00E+00
acenaphthene	6.97E-04			1.91E-04	8.18E-05		0.00E+00
fluorene	5.10E-04			1.40E-04	5.99E-05		0.00E+00
anthracene	2.78E-05			7.62E-06	3.26E-06		0.00E+00
fluoranthene	2.57E-05			7.04E-06	3.02E-06		0.00E+00
pyrene	1.18E-07		4.9E-01	3.23E-08	1.39E-08		6.84E-09
benzo(a)anthracene	2.40E-04		8.8E-01	6.58E-05	2.82E-05		2.49E-05
bis-(2-ethylhexyl)phthalate	2.34E-04			6.41E-05	2.75E-05		0.00E+00
chrysene	1.62E-06		2.7E-02	4.44E-07	1.90E-07		5.14E-09
benzo(b)fluoranthene	7.84E-02		8.5E-01	2.15E-02	9.21E-03		7.86E-03
benzo(k)fluoranthene	1.48E-02		4.0E-01	4.05E-03	1.74E-03		7.00E-04
benzo(a)pyrene	3.69E-05		6.1E+00	1.01E-05	4.33E-06		2.64E-05
indeno(1,2,3,c,d)pyrene	2.34E-04		1.4E+00	6.41E-05	2.75E-05		3.87E-05
benzo(g,h,i,c,d)perylene	2.34E-04		1.3E-01	6.41E-05	2.75E-05		3.68E-06
arochlor-1242	4.41E-05			1.21E-05	5.18E-06		0.00E+00
arochlor-1260	1.84E-05			5.04E-06	2.16E-06		0.00E+00
TOTAL						2.04E-01	8.75E-03

Table J-15
 Lenz Oil Baseline Risk Assessment
 Residential/soil ingestion/children/6 year exposure
 Area B

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		1.32E-07	1.13E-08	2.19E-06	0.00E+00
acetone	7.57E-02	1E-01		9.68E-07	8.30E-08	9.68E-06	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		4.47E-08	3.84E-09	4.47E-07	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		7.88E-08	6.75E-09	3.94E-06	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	9.33E-08	8.00E-09		7.28E-10
trichloroethane,1,1,1	2.58E-02	9E-02		3.30E-07	2.83E-08	3.67E-06	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		7.54E-08	6.47E-09	2.51E-04	0.00E+00
trichloroethene	4.01E-02		1.1E-02	5.13E-07	4.39E-08		4.83E-10
Benzene	5.99E-03		3E-02	7.66E-08	6.56E-09		1.90E-10
methyl,4-2-pentanone	6.12E-03			7.82E-08	6.71E-09		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	2.92E-07	2.50E-08	2.92E-05	1.27E-09
toluene	6.94E-03	2E-01		8.87E-08	7.61E-09	4.44E-07	0.00E+00
ethylbenzene	1.14E-02	1E-01		1.46E-07	1.25E-08	1.46E-06	0.00E+00
xylenes (total)	2.15E-02	2E+00		2.75E-07	2.36E-08	1.37E-07	0.00E+00
naphthalene	8.20E-02	4E-02		1.05E-06	8.99E-08	2.62E-05	0.00E+00
methnaphthalene,2	7.70E-02			9.84E-07	8.44E-08		0.00E+00
acenaphthene	1.40E-01	6E-02		1.79E-06	1.53E-07	2.98E-05	0.00E+00
dibenzofuran	1.20E-01			1.53E-06	1.32E-07		0.00E+00
fluorene	2.21E-01	4E-02		2.83E-06	2.42E-07	7.06E-05	0.00E+00
phenanthrene	5.47E-01			6.99E-06	5.99E-07		0.00E+00
anthracene	2.75E-01	3E-01		3.52E-06	3.01E-07	1.17E-05	0.00E+00
fluoranthene	7.88E-01	4E-02		1.01E-05	8.64E-07	2.52E-04	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	8.41E-06	7.21E-07	2.80E-04	3.39E-07
butylbenzylphthalate	2.29E-01	2E-01		2.93E-06	2.51E-07	1.46E-05	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	6.00E-06	5.14E-07		4.32E-07
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	2.05E-06	1.75E-07	1.02E-04	2.45E-09
chrysene	4.34E-01		2.5E-02	5.55E-06	4.76E-07		1.19E-08
benzo(b)fluoranthene	4.54E-01		8.1E-01	5.80E-06	4.98E-07		4.04E-07
benzo(k)fluoranthene	4.35E-01		3.8E-01	5.56E-06	4.77E-07		1.83E-07
benzo(a)pyrene	4.54E-01		5.8E+00	5.80E-06	4.98E-07		2.89E-06
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	3.58E-06	3.07E-07		4.14E-07
benzo(g,h,i)perylene	2.88E-01		1.3E-01	3.68E-06	3.16E-07		4.04E-07
Gamma-BHC	1.30E-03	3E-04		1.66E-08	1.42E-09	5.54E-05	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	2.43E-08	2.08E-09	8.10E-04	3.54E-08
endosulfan I	5.20E-03			6.65E-08	5.70E-09		0.00E+00
DDE	2.10E-02		3.4E+01	2.68E-07	2.30E-08		7.82E-07
DDD	9.94E-03		2.4E+01	1.27E-07	1.09E-08		2.61E-07
DDT	1.28E-02	5E-04	3.4E-01	1.64E-07	1.40E-08	3.27E-04	4.77E-09
alpha chlordane	3.11E-03	6E-05	1.3E+00	3.98E-08	3.41E-09	6.63E-04	4.43E-09
gamma chlordane	2.94E-03	6E-05	1.3E+00	3.76E-08	3.22E-09	6.26E-04	4.19E-09
aro-chlor-1242	1.42E-01		7.7E+00	1.82E-06	1.56E-07		1.20E-06
aro-chlor-1254	6.02E-02		7.7E+00	7.70E-07	6.60E-08		5.08E-07
calcium	1.01E+05			1.29E+00	1.11E-01		0.00E+00
chromium	3.33E+01	1E+00		4.26E-04	3.65E-05	4.26E-04	0.00E+00
lead	3.53E+02			4.51E-03	3.87E-04		0.00E+00
magnesium	5.65E+04			7.22E-01	6.19E-02		0.00E+00
cadmium	1.03E+00	1E-03		1.32E-05	1.13E-06	1.32E-02	0.00E+00
Total-child						1.72E-02	7.51E-06

Table J-16
 Lenz Oil Baseline Risk Assessment
 Residential/soil/dermal/children only/6 year exposure

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day) -	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		1.73E-07	1.48E-08	2.88E-06	0.00E+00
acetone	7.57E-02	1E-01		1.27E-06	1.09E-07	1.27E-05	0.00E+00
dichloroethane,1,1	3.50E-03	1E-01		5.86E-08	5.02E-09	5.86E-07	0.00E+00
dichloroethane,1,2	6.16E-03	2E-02		1.03E-07	8.84E-09	5.16E-06	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	1.22E-07	1.05E-08		9.54E-10
trichloroethane,1,1,1	2.58E-02	9E-02		4.32E-07	3.70E-08	4.80E-06	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-04		9.88E-08	8.47E-09	3.29E-04	0.00E+00
trichloroethene	4.01E-02		1.1E-02	6.72E-07	5.76E-08		6.33E-10
Benzene	5.99E-03		2.9E-02	1.00E-07	8.60E-09		2.49E-10
methyl,4-2-pentanone	6.12E-03			1.03E-07	8.79E-09		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	3.82E-07	3.27E-08	3.82E-05	1.67E-09
toluene	6.94E-03	2E-01		1.16E-07	9.96E-09	5.81E-07	0.00E+00
ethylbenzene	1.14E-02	1E-01		1.91E-07	1.64E-08	1.91E-06	0.00E+00
xylene (total)	2.15E-02	2E+00		3.60E-07	3.09E-08	1.80E-07	0.00E+00
naphthalene	8.20E-02	4E-02		5.49E-07	4.71E-08	1.37E-05	0.00E+00
methnaphthalene,2	7.70E-02			5.16E-07	4.42E-08		0.00E+00
acenaphthene	1.40E-01	6E-02		9.38E-07	8.04E-08	1.56E-05	0.00E+00
dibenzofuran	1.20E-01			8.04E-07	6.89E-08		0.00E+00
fluorene	2.21E-01	4E-02		1.48E-06	1.27E-07	3.70E-05	0.00E+00
phenanthrene	5.47E-01			3.66E-06	3.14E-07		0.00E+00
anthracene	2.75E-01	3E-01		1.84E-06	1.58E-07	6.14E-06	0.00E+00
fluoranthene	7.88E-01	4E-02		5.28E-06	4.53E-07	1.32E-04	0.00E+00
pyrene	6.58E-01	3E-02	4.7E-01	4.41E-06	3.78E-07	1.47E-04	1.78E-07
butylbenzylphthalate	2.29E-01	2E-01		1.53E-06	1.32E-07	7.67E-06	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	3.14E-06	2.69E-07		2.26E-07
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	1.07E-06	9.19E-08	5.36E-05	1.29E-09
chrysene	4.34E-01		2.5E-02	2.91E-06	2.49E-07		6.23E-09
benzo(b)fluoranthene	4.54E-01		8.1E-01	3.04E-06	2.61E-07		2.12E-07
benzo(k)fluoranthene	4.35E-01		3.8E-01	2.91E-06	2.50E-07		9.57E-08
benzo(a)pyrene	4.54E-01		5.8E+00	3.04E-06	2.61E-07		1.51E-06
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	1.88E-06	1.61E-07		2.17E-07
benzo(g,h,i)perylene	2.88E-01		1.3E-01	1.93E-06	1.65E-07		2.12E-08
Gamma-BHC	1.30E-03	3E-04		8.71E-09	7.47E-10	2.90E-05	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	1.27E-08	1.09E-09	4.24E-04	1.85E-08
endosulfan I	5.20E-03			3.48E-08	2.99E-09		0.00E+00
DDE	2.10E-02		3.4E+01	1.41E-07	1.21E-08		4.10E-07
DDD	9.94E-03		2.4E+01	6.66E-08	5.71E-09		1.37E-07
DDT	1.28E-02	5E-04	3.4E-01	8.58E-08	7.35E-09	1.72E-04	2.50E-09
alpha chlordane	3.11E-03	6E-05	1.3E+00	2.08E-08	1.79E-09	3.47E-04	2.32E-09
gamma chlordane	2.94E-03	6E-05	1.3E+00	1.97E-08	1.69E-09	3.28E-04	2.19E-09
rochlor-1242	1.42E-01		7.7E+00	9.51E-07	8.15E-08		6.28E-07
rochlor-1254	6.02E-02		7.7E+00	4.03E-07	3.46E-08		2.66E-07
calcium	1.01E+05			6.77E-02	5.80E-03		0.00E+00
chromium	3.33E+01	1E+00		2.23E-05	1.91E-06	2.23E-05	0.00E+00
lead	3.53E+02			2.36E-04	2.03E-05		0.00E+00
magnesium	5.65E+04			3.79E-02	3.24E-03		0.00E+00
cadmium	1.03E+00	1E-03		6.90E-07	5.91E-08	6.90E-04	0.00E+00
Total-child						2.82E-03	3.94E-06

Table J-17
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/ingestion/onsite/upper aquifer

Adult

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Benzene	1.36E-01	1E-02	2.9E-02	3.73E-03	1.60E-03	3.73E-01	4.63E-05
Acetone	1.00E-02	1E-01					
Chloroform	8.97E-03	1E-02	6.1E-03	2.46E-04	1.05E-04	2.46E-02	6.42E-07
1,1-Dichloroethene	4.50E-03	1E-01	0.0E+00	9.86E-05	4.23E-05	9.86E-04	0.00E+00
1,2-Dichloroethene	3.00E-03	2E-02	0.0E+00	8.22E-05	3.52E-05	4.11E-03	0.00E+00
Di-n-butyl phthalate	1.00E-03	1E+01	0.0E+00	2.74E-05	1.17E-05	2.74E-06	0.00E+00
Ethylbenzene	2.02E-01	1E-01	0.0E+00	4.43E-03	1.90E-03	4.43E-02	0.00E+00
Total xylenes	7.28E-01	2E+00	0.0E+00	1.60E-02	6.84E-03	7.98E-03	0.00E+00
Naphthalene	7.06E-01	4E-02	0.0E+00	1.55E-02	6.63E-03	3.87E-01	0.00E+00
2-Methyl naphthalene	3.36E+00		0.0E+00	7.36E-02	3.15E-02		0.00E+00
Fluorene	3.34E-01	4E-02	0.0E+00	7.32E-03	3.14E-03	1.83E-01	0.00E+00
PCB	2.05E-01		7.7E+00	4.49E-03	1.92E-03		1.48E-02
Phenanthrene	8.08E-01		0.0E+00	1.77E-02	7.59E-03		0.00E+00
Chloroethane	4.97E-01		0.0E+00	1.09E-02	4.67E-03		0.00E+00
Methylene chloride	4.69E-02	6E-02	0.0E+00	1.03E-03	4.41E-04	1.71E-02	0.00E+00
1,1-Dichloroethane	1.36E-02	1E-01	0.0E+00	2.98E-04	1.28E-04	2.98E-03	0.00E+00
Trichloroethene	2.20E-03		1.1E-02	4.82E-05	2.07E-05		2.27E-07
Toluene	6.30E-02	2E-01	0.0E+00	1.38E-03	5.92E-04	6.90E-03	0.00E+00
Acenaphthene	5.53E-02	6E-02	0.0E+00	1.21E-03	5.19E-04	2.02E-02	0.00E+00
Dibenzofuran	5.84E-02		0.0E+00	1.28E-03	5.49E-04		0.00E+00
Beryllium	1.97E-03	5E-03	0.0E+00	4.32E-05	1.85E-05	8.64E-03	0.00E+00
Total-adult						1.08E+00	1.49E-02

Residential-child

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Benzene	1.36E-01	1E-02	2.9E-02	1.74E-03	7.45E-04	1.74E-01	2.16E-05
Acetone	1.00E-02	1E-01					
Chloroform	8.97E-03	1E-02	6.1E-03	1.15E-04	4.92E-05	1.15E-02	3.00E-06
1,1-Dichloroethene	4.50E-03	1E-01	0.0E+00	5.75E-05	2.47E-05	5.75E-04	0.00E+00
1,2-Dichloroethene	3.00E-03	2E-02	0.0E+00	3.84E-05	1.64E-05	1.92E-03	0.00E+00
Di-n-butyl phthalate	1.00E-03	1E+01	0.0E+00	1.28E-05	5.48E-06	1.28E-06	0.00E+00
Ethylbenzene	2.02E-01	1E-01	0.0E+00	2.58E-03	1.11E-03	2.58E-02	0.00E+00
Total xylenes	7.28E-01	2E+00	0.0E+00	9.31E-03	3.99E-03	4.65E-03	0.00E+00
Naphthalene	7.06E-01	4E-02	0.0E+00	9.03E-03	3.87E-03	2.26E-01	0.00E+00
2-Methyl naphthalene	3.36E+00		0.0E+00	4.29E-02	1.84E-02		0.00E+00
Fluorene	3.34E-01	4E-02	0.0E+00	4.27E-03	1.83E-03	1.07E-01	0.00E+00
PCB	2.05E-01		7.7E+00	2.62E-03	1.12E-03		8.64E-03
Phenanthrene	8.08E-01		0.0E+00	1.03E-02	4.43E-03		0.00E+00
Chloroethane	4.97E-02		0.0E+00	6.35E-04	2.72E-04		0.00E+00
Methylene chloride	4.69E-02	6E-02	0.0E+00	6.00E-04	2.57E-04	9.99E-03	0.00E+00
1,1-Dichloroethane	1.36E-02	1E-01	0.0E+00	1.74E-04	7.45E-05	1.74E-03	0.00E+00
Trichloroethene	2.20E-03		1.1E-02	2.81E-05	1.21E-05		1.33E-07
Toluene	6.30E-02	2E-01	0.0E+00	8.05E-04	3.45E-04	4.03E-03	0.00E+00
Acenaphthene	5.53E-02	6E-02	0.0E+00	7.07E-04	3.03E-04	1.18E-02	0.00E+00
Dibenzofuran	5.84E-02		0.0E+00	7.47E-04	3.20E-04		0.00E+00
Beryllium	1.97E-03	5E-03	0.0E+00	2.52E-05	1.08E-05	5.04E-03	0.00E+00
Total-child						5.83E-01	8.66E-03
Total-adult/child						1.66E+00	2.35E-02

Table J-18
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/dermal/onsite/upper aquifer

Adult

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Benzene	1.36E-01			6.63E-05	2.84E-05		0.00E+00
Acetone	1.00E-02	1E-01		4.88E-06	2.09E-06	4.88E-05	0.00E+00
Chloroform	8.97E-03	1E-02	6.1E-03	4.37E-06	1.87E-06	4.37E-04	1.14E-08
1,1-Dichloroethene	4.50E-03	1E-01	0.0E+00	3.95E-06	1.69E-06	3.95E-05	0.00E+00
1,2-Dichloroethene	3.00E-03	2E-02	0.0E+00	1.64E-06	7.05E-07	8.22E-05	0.00E+00
Di-n-butyl phthalate	1.00E-03	1E+01	0.0E+00	1.81E-06	7.75E-07	1.81E-07	0.00E+00
Ethylbenzene	2.02E-01	1E-01	0.0E+00	8.19E-04	3.51E-04	8.19E-03	0.00E+00
Total xylenes	7.28E-01	2E+00	0.0E+00	3.19E-03	1.37E-03	1.60E-03	0.00E+00
Naphthalene	7.06E-01	4E-02	0.0E+00	2.67E-03	1.14E-03	6.67E-02	0.00E+00
2-Methyl naphthalene	3.36E+00		0.0E+00	1.54E-04	6.62E-05		0.00E+00
Fluorene	3.34E-01	4E-02	0.0E+00	1.54E-05	6.59E-06		0.00E+00
PCB	2.05E-01		7.7E+00	7.97E-03	3.41E-03		2.63E-02
Phenanthrene	8.08E-01		0.0E+00	1.02E-02	4.36E-03		0.00E+00
Chloroethane	4.97E-02	2E+00	0.0E+00	2.18E-05	9.34E-06	1.09E-05	0.00E+00
Methylene chloride	4.69E-02	6E-02	0.0E+00	1.16E-05	4.96E-06	1.93E-04	0.00E+00
1,1-Dichloroethane	1.36E-02	1E-01	0.0E+00	6.63E-06	2.84E-06	6.63E-05	0.00E+00
Trichloroethene	2.20E-03		1.1E-02	1.93E-06	8.27E-07		9.09E-09
Toluene	6.30E-02	2E-01	0.0E+00	1.55E-04	6.66E-05	7.77E-04	0.00E+00
Acenaphthene	5.53E-02	6E-02	0.0E+00	2.55E-06	1.09E-06	4.24E-05	0.00E+00
Dibenzofuran	5.84E-02		0.0E+00	2.69E-06	1.15E-06		0.00E+00
Beryllium	1.97E-03	5E-03	0.0E+00	9.07E-08	3.89E-08	1.81E-05	0.00E+00
Total-adult						7.82E-02	2.63E-02

Residential-child

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Benzene	1.36E-01			3.04E-05	1.30E-05		0.00E+00
Acetone	1.00E-02	1E-02		2.24E-06	9.58E-07	2.24E-04	0.00E+00
Chloroform	8.97E-03	1E-02	6.1E-03	2.01E-06	8.60E-07	2.01E-04	5.24E-09
1,1-Dichloroethene	4.50E-03	1E-01	0.0E+00	1.81E-06	7.75E-07	1.81E-05	0.00E+00
1,2-Dichloroethene	3.00E-03	2E-02	0.0E+00	7.54E-07	3.23E-07	3.77E-05	0.00E+00
Di-n-butyl phthalate	1.00E-03	1E+01	0.0E+00	8.29E-07	3.55E-07	8.29E-08	0.00E+00
Ethylbenzene	2.02E-01	1E-01	0.0E+00	3.76E-04	1.61E-04	3.76E-03	0.00E+00
Total xylenes	7.28E-01	2E+00	0.0E+00	1.46E-03	6.27E-04	7.32E-04	0.00E+00
Naphthalene	7.06E-01	4E-02	0.0E+00	1.22E-03	5.25E-04	3.06E-02	0.00E+00
2-Methyl naphthalene	3.36E+00		0.0E+00	7.08E-05	3.04E-05		0.00E+00
Fluorene	3.34E-01	4E-02	0.0E+00	7.05E-06	3.02E-06		0.00E+00
PCB	2.05E-01		7.7E+00	3.65E-03	1.57E-03		1.21E-02
Phenanthrene	8.08E-01		0.0E+00	4.67E-03	2.00E-03		0.00E+00
Chloroethane	4.97E-02	2E+00	0.0E+00	9.99E-06	4.28E-06	4.99E-06	0.00E+00
Methylene chloride	4.69E-02	6E-02	0.0E+00	5.30E-06	2.27E-06	8.84E-05	0.00E+00
1,1-Dichloroethane	1.36E-02	1E-01	0.0E+00	3.04E-06	1.30E-06	3.04E-05	0.00E+00
Trichloroethene	2.20E-03		1.1E-02	8.84E-07	3.79E-07		4.17E-09
Toluene	6.30E-02	2E-01	0.0E+00	7.12E-05	3.05E-05	3.56E-04	0.00E+00
Acenaphthene	5.53E-02	6E-02	0.0E+00	1.17E-06	5.00E-07	1.95E-05	0.00E+00
Dibenzofuran	5.84E-02		0.0E+00	1.23E-06	5.28E-07		0.00E+00
Beryllium	1.97E-03	5E-03	0.0E+00	4.16E-08	1.78E-08	8.31E-06	0.00E+00
Total-child						3.61E-02	1.21E-02
TOTAL-adult/child						1.14E-01	3.83E-02

Table J-19
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/inhalation/excavated area (a)/upper aquifer

Adult

Chemical	Conc.(mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	1.80E-02		1.2E+00	3.70E-05	1.59E-05		1.90E-05
1,1-Dichloroethane	5.60E-02		0.0E+00	1.15E-04	4.93E-05		0.00E+00
1,2-Dichloroethene	7.00E-03		0.0E+00	1.44E-05	6.16E-06		0.00E+00
Chloroethane	2.38E-01			4.89E-04	2.10E-04		0.00E+00
Chloroform	3.40E-02		2.9E-01	6.99E-05	2.99E-05		8.68E-06
Ethylbenzene	8.07E-01	3E-01	0.0E+00	1.66E-03	7.11E-04	5.53E-03	0.00E+00
Trichloroethene	8.00E-03		1.7E-02	1.64E-05	7.05E-06		1.20E-07
Di-n-butyl phthalate	1.00E-03			2.05E-06	8.81E-07		0.00E+00
Xylenes	2.87E+00		0.0E+00	5.89E-03	2.52E-03		0.00E+00
Benzene	3.53E-01		2.9E-02	7.25E-04	3.11E-04		9.01E-06
Toluene	2.65E-01	4E-01	0.0E+00	5.45E-04	2.33E-04	1.36E-03	0.00E+00
Phenanthrene	4.38E-01		0.0E+00	9.00E-04	3.86E-04		0.00E+00
TOTAL						6.89E-03	3.68E-05

File-onugwihl

Table J-20
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/ingestion/onsite/lower aquifer

Adult

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Chlorethane	2.29E-02		0.0E+00	6.27E-04	2.69E-04		0.00E+00
Diethylphthalate	6.42E-03	8E+00	0.0E+00	1.76E-04	7.54E-05	2.20E-05	0.00E+00
Toluene	4.54E-03	2E-01	0.0E+00	1.24E-04	5.33E-05	6.22E-04	0.00E+00
Di-n-butyl phthalate	6.42E-03	1E+01	0.0E+00	1.76E-04	7.54E-05	1.76E-05	0.00E+00
Benzene	5.94E-03		2.9E-02	1.63E-04	6.97E-05		2.02E-06
Total-adult						6.61E-04	2.02E-06

Residential\child

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Chlorethane	2.29E-02		0.0E+00	2.93E-04	1.25E-04		0.00E+00
Diethylphthalate	6.42E-03	8E+00	0.0E+00	8.21E-05	3.52E-05	1.03E-05	0.00E+00
Toluene	4.54E-03	2E-01	0.0E+00	5.80E-05	2.49E-05	2.90E-04	0.00E+00
Di-n-butyl phthalate	6.42E-03	1E+01	0.0E+00	8.21E-05	3.52E-05	8.21E-06	0.00E+00
Benzene	5.94E-03		2.9E-02	7.59E-05	3.25E-05		9.44E-07
Total-child						3.09E-04	9.44E-07
Total-adult/child						9.70E-04	2.97E-06

Table J-21
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/dermal/onsite/lower aquifer

Adult

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Benzene	5.94E-03		2.9E-02	1.56E-06	6.70E-07		1.94E-08
Chlorethane	2.29E-02		0.0E+00	5.65E-05	2.42E-05		0.00E+00
Diethylphthalate	1.00E-03	8E+00	0.0E+00	1.81E-06	7.75E-07	2.26E-07	0.00E+00
Toluene	4.00E-03	2E-01	0.0E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Di-n-butyl phthalate	1.00E-03	1E+01	0.0E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total-adult						2.26E-07	1.94E-08

Residential-child

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR mg/kg-day)	HQ	Risk
Benzene	5.94E-03		2.9E-02	1.19E-06	5.12E-07		1.48E-08
Chlorethane	2.29E-02		0.0E+00	4.60E-06	1.97E-06		0.00E+00
Diethylphthalate	1.00E-03	8E+00	0.0E+00	1.21E-07	5.17E-08	1.51E-08	0.00E+00
Toluene	4.00E-03	2E-01	0.0E+00	4.52E-06	1.94E-06	2.26E-05	0.00E+00
Di-n-butyl phthalate	1.00E-03	1E+01	0.0E+00	8.29E-07	3.55E-07	8.29E-08	0.00E+00
TOTAL-child						2.27E-05	1.48E-08
TOTAL-adult/child						2.29E-05	3.43E-08

Table J-22
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/inhalation/excavated area (a)/lower aquifer

Adult

Chemical	Conc.(mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Di-n-butyl phthalate	1.10E-01			2.26E-04	9.69E-05		0.00E+00
Chloroethane	1.10E-01		0.0E+00	2.26E-04	9.69E-05		0.00E+00
Diethylphthalate	4.00E-03		0.0E+00	8.22E-06	3.52E-06		0.00E+00
Toluene	1.70E-02		0.0E+00	3.49E-05	1.50E-05		0.00E+00
Benzene	1.50E-02		2.90E-02	3.08E-05	1.32E-05		3.83E-07
TOTAL						0.00E+00	3.83E-07

Table J-23
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/ingestion/offsite/upper aquifer

Adult

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	5.00E-03	9E-03	6.0E-01	1.10E-04	4.70E-05	1.22E-02	2.82E-05
1,1-Dichloroethane	7.00E-02	1E-01	0.0E+00	1.53E-03	6.58E-04	1.53E-02	0.00E+00
1,2-Dichloroethene	2.10E-02	2E-02	6.0E-01	4.60E-04	1.97E-04	2.30E-02	1.18E-04
Di-n-butyl phthalate	3.00E-03	1E+01	0.0E+00	6.58E-05	2.82E-05	6.58E-06	0.00E+00
1,1,1-Trichloroethane	1.20E-01	9E-02	0.0E+00	2.63E-03	1.13E-03	2.92E-02	0.00E+00
Trichloroethene	6.00E-03		0.0E+00	1.32E-04	5.64E-05		0.00E+00
Vinyl chloride	1.26E-02		1.9E+00	2.76E-04	1.18E-04		2.25E-04
Tetrachlorethene	3.00E-03	1E-02	5.1E-02	6.58E-05	2.82E-05	6.58E-03	1.44E-06
Chloroethane	5.00E-03		0.0E+00	1.10E-04	4.70E-05		0.00E+00
Total-adult						8.63E-02	3.73E-04

Residential-child

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	5.00E-03	9E-03	6.0E-01	6.39E-05	2.74E-05	7.10E-03	1.64E-05
1,1-Dichloroethane	7.00E-02	1E-01	0.0E+00	8.95E-04	3.84E-04	8.95E-03	0.00E+00
1,2-Dichloroethene	2.10E-02	2E-02	6.0E-01	2.68E-04	1.15E-04	1.34E-02	6.90E-05
Di-n-butyl phthalate	3.00E-03	1E+01	0.0E+00	3.84E-05	1.64E-05	3.84E-06	0.00E+00
1,1,1-Trichloroethane	3.00E-03	1E-02	5.1E-02	3.84E-05	1.64E-05	3.84E-03	8.38E-07
Trichloroethene	6.00E-03		0.0E+00	7.67E-05	3.29E-05		0.00E+00
Vinyl chloride	1.26E-02		1.9E+00	1.61E-04	6.90E-05		1.31E-04
Tetrachlorethene	1.20E-01	9E-02	0.0E+00	1.53E-03	6.58E-04	1.70E-02	0.00E+00
Chloroethane	5.00E-03		0.0E+00	6.39E-05	2.74E-05		0.00E+00
Total-child						5.04E-02	2.17E-04
Total-adult/child						1.37E-01	5.90E-04

Table J-24

Lenz Oil Baseline Risk Assessment

Residential/groundwater/dermal/offsite upper aquifer

Adult

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	5.00E-03	9E-03	6.0E-01	4.38E-06	1.88E-06	4.87E-04	1.13E-06
1,1-Dichloroethane	7.00E-02	1E-01	0.0E+00	3.41E-05	1.46E-05	3.41E-04	0.00E+00
1,2-Dichloroethene	2.10E-02	2E-02	6.0E-01	1.15E-05	4.93E-06	5.75E-04	2.96E-06
Di-n-butyl phthalate	3.00E-03	1E+01	0.0E+00	5.42E-06	2.32E-06	5.42E-07	0.00E+00
1,1,1-Trichloroethane	1.20E-01	9E-02	0.0E+00	1.12E-04	4.79E-05	1.24E-03	0.00E+00
Trichloroethene	6.00E-03	4E-02	0.0E+00	5.26E-06	2.25E-06	1.32E-04	0.00E+00
Vinyl chloride	1.26E-02		1.9E+00	5.04E-06	2.16E-06		4.10E-06
Tetrachlorethene	3.00E-03	1E-02	5.1E-02	1.48E-06	6.34E-07	1.48E-04	3.23E-08
Chloroethane	5.00E-03		0.0E+00	2.19E-06	9.39E-07		0.00E+00
Total-adult						2.93E-03	8.22E-06

Residential-child

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	5.00E-03	9E-03	6.0E-01	2.01E-06	8.61E-07	2.23E-04	5.17E-07
1,1-Dichloroethane	7.00E-02	1E-01	0.0E+00	1.57E-05	6.71E-06	1.57E-04	0.00E+00
1,2-Dichloroethene	2.10E-02	2E-02	6.0E-01	5.28E-06	2.26E-06	2.64E-04	1.36E-06
Di-n-butyl phthalate	3.00E-03	1E+01	0.0E+00	2.49E-06	1.07E-06	2.49E-07	0.00E+00
1,1,1-Trichloroethane	1.20E-01	9E-02	0.0E+00	5.13E-05	2.20E-05	5.69E-04	0.00E+00
Trichloroethene	6.00E-03	4E-02	0.0E+00	2.41E-06	1.03E-06	6.03E-05	0.00E+00
Vinyl chloride	1.26E-02		1.9E+00	2.31E-06	9.90E-07		1.88E-06
Tetrachlorethene	3.00E-03	1E-02	2.0E-01	6.78E-07	2.91E-07	6.78E-05	5.81E-08
Chloroethane	5.00E-03		0.0E+00	1.00E-06	4.31E-07		0.00E+00
Total-child						1.34E-03	3.81E-06
TOTAL-adul/child						4.27E-03	1.20E-05

Table J-25

Lenz Oil Baseline Risk Assessment

Residential/Groundwater/inhalation/nonexcavated area (b)/upper aquifer

Adult

Chemical	Conc.(mg/m3)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	2.00E-02	1.2E+00	4.11E-05	1.76E-05		2.11E-05
1,1-Dichloroethane	3.65E-01	0.0E+00	7.50E-04	3.21E-04		0.00E+00
1,2-Dichloroethene	4.80E-02	0.0E+00	9.86E-05	4.23E-05		0.00E+00
1,1,1-Trichloroethane	4.06E-01	0.0E+00	8.34E-04	3.58E-04		0.00E+00
Trichloroethene	2.20E-02	1.7E-02	4.52E-05	1.94E-05		3.29E-07
Vinyl chloride	6.20E-02	2.90E-01	1.27E-04	5.46E-05		1.58E-05
Di-n-Butyl Phthalate	2.00E-03		4.11E-06	1.76E-06		0.00E+00
Chloroethane	2.40E-02		4.93E-05	2.11E-05		0.00E+00
Tetrachlorethene	1.00E-02	1.85E-03	2.05E-05	8.81E-06		1.63E-08
TOTAL					0.00E+00	3.73E-05

Table J-26
 Lenz Oil Site Baseline Risk Assessment
 Residential/groundwater/ingestion/offsite/lower aquifer

Adult

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Zinc	2.20E-02	1.0E-02	2.00E-01	4.82E-04	2.07E-04	4.82E-02	4.13E-05
1,2-Dichloroethene	1.00E-02	1.0E-02	0.00E+00	2.19E-04	9.39E-05	2.19E-02	0.00E+00
1,1-Dichloroethane	5.80E-02	1.0E-01	0.00E+00	1.27E-03	5.45E-04	1.27E-02	0.00E+00
1,1-Dichloroethene	3.00E-03	9.0E-03	6.00E-01	6.58E-05	2.82E-05	7.31E-03	1.69E-05
1,1,1-Trichloroethane	6.20E-02	9.0E-02	0.00E+00	1.36E-03	5.82E-04	1.51E-02	0.00E+00
Vinyl chloride	1.50E-02		1.90E+00	3.29E-04	1.41E-04		2.68E-04
Di-N-butyl phthalate	1.00E-03	1.0E-01	0.00E+00	2.19E-05	9.39E-06	2.19E-04	0.00E+00
Calcium	1.86E+02						
Chromium	4.20E-02	5.0E-03		9.21E-04	3.95E-04	1.84E-01	0.00E+00
Total-adult						2.90E-01	3.26E-04

Residential-child

Chemical	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Zinc	2.20E-02	2.0E-01	0.00E+00	2.81E-04	1.21E-04	1.41E-03	0.00E+00
1,2-Dichloroethene	1.00E-02	1.0E-02	0.00E+00	1.28E-04	5.48E-05	1.28E-02	0.00E+00
1,1-Dichloroethane	5.80E-02	1.0E-01	0.00E+00	7.42E-04	3.18E-04	7.42E-03	0.00E+00
1,1-Dichloroethene	3.00E-03	9.0E-03	6.00E-01	3.84E-05	1.64E-05	4.26E-03	9.86E-06
1,1,1-Trichloroethane	6.20E-02	9.0E-02	0.00E+00	7.93E-04	3.40E-04	8.81E-03	0.00E+00
Vinyl chloride	1.50E-02		1.90E+00	1.92E-04	8.22E-05		1.56E-04
Di-N-butyl phthalate	1.00E-03	1.0E-01	0.00E+00	1.28E-05	5.48E-06	1.28E-04	0.00E+00
Calcium	1.86E+02						
Chromium	4.20E-02	5.0E-03	0.00E+00	5.37E-04	2.30E-04	1.07E-01	0.00E+00
Total-child						1.42E-01	1.66E-04
Total-adult/child						4.32E-01	4.92E-04

File-offlgwig

Table J-27
 Lenz Oil Baseline Risk Assessment
 Residential/groundwater/dermal/offsite/lower aquifer

Adult

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Zinc	2.20E-02	1.0E-02	2.00E-01	1.21E-05	5.17E-06	1.21E-03	1.03E-06
1,2-Dichloroethene	1.00E-02	1.0E-02	0.00E+00	5.48E-06	2.35E-06	5.48E-04	0.00E+00
1,1-Dichloroethane	5.80E-02	1.0E-01	0.00E+00	2.83E-05	1.21E-05	2.83E-04	0.00E+00
1,1-Dichloroethene	3.00E-03	9.0E-03	6.00E-01	2.63E-06	1.13E-06	2.92E-04	6.76E-07
1,1,1-Trichlorethane	6.20E-02	9.0E-02	0.00E+00	5.78E-05	2.48E-05	6.42E-04	0.00E+00
Vinyl chloride	1.50E-02		1.90E+00	6.00E-06	2.57E-06		4.89E-06
Di-N-butyl phthalate	1.00E-03	1.0E-01	0.0E+00	1.81E-06	7.75E-07	1.81E-05	0.00E+00
Calcium	1.86E+02						
Chromium	4.20E-02	5.0E-03	0.0E+00	7.59E-05	3.25E-05	1.52E-02	0.00E+00
Total-adult						1.82E-02	6.60E-06

Residential-child

Chemicals	Conc. (mg/l)	RfD (mg/kg-day)	SF(mg/kg-day) ⁻¹	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
Zinc	2.20E-02	1.0E-02	2.00E-01	5.53E-06	2.37E-06	5.53E-04	4.74E-07
1,2-Dichloroethene	1.00E-02	1.0E-02	0.00E+00	2.51E-06	1.08E-06	2.51E-04	0.00E+00
1,1-Dichloroethane	5.80E-02	1.0E-01	0.00E+00	1.30E-05	5.56E-06	1.30E-04	0.00E+00
1,1-Dichloroethene	3.00E-03	9.0E-03	6.00E-01	1.21E-06	5.17E-07	1.34E-04	3.10E-07
1,1,1-Trichlorethane	6.20E-02	9.0E-02	0.00E+00	2.65E-05	1.13E-05	2.94E-04	0.00E+00
Vinyl chloride	1.50E-02		1.90E+00	2.75E-06	1.18E-06		2.24E-06
Di-N-butyl phthalate	1.00E-03	1.0E-01	0.0E+00	8.29E-07	3.55E-07	8.29E-06	0.00E+00
Calcium	1.86E+02						
Chromium	4.20E-02	5.0E-03	0.0E+00	3.48E-05	1.49E-05	6.96E-03	0.00E+00
TOTAL-child						8.33E-03	3.02E-06
TOTAL-adult/child						2.65E-02	9.62E-06

File-offlgwde

Table J-28

Lenz Oil Baseline Risk Assessment

Residential/Groundwater/inhalation/nonexcavated area (b)/lower aquifer

Adult

Chemical	Conc. (mg/m3)	SF (mg/kg-day) -1	Intake - NC (mg/kg-day)	Intake - CAR (mg/kg-day)	HQ	Risk
1,1-Dichloroethene	1.20E-02	1.2E+00	2.47E-05	1.06E-05		1.27E-05
1,1-Dichloroethane	2.35E-01	0.0E+00	4.83E-04	2.07E-04		0.00E+00
1,2-Dichloroethene	2.30E-02	0.0E+00	4.73E-05	2.03E-05		0.00E+00
1,1,1-Trichloroethane	2.10E-01	0.0E+00	4.32E-04	1.85E-04		0.00E+00
Vinyl chloride	7.40E-02	2.9E-01	1.52E-04	6.52E-05		1.89E-05
Di-n-Butyl Phthalate	1.00E-03		2.05E-06	8.81E-07		0.00E+00
TOTAL					0.00E+00	3.16E-05

Table J-29
 Lenz Oil Baseline Risk Assessment
 Short-term Worker/ingestion/soil
 Area B

Chemical	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		7.06E-08	1.38E-10	1.18E-06	0.00E+00
acetone	7.57E-02	1E+00		5.19E-07	1.02E-09	5.19E-07	0.00E+00
dichloroethane,1,1	3.50E-03	1E+00		2.40E-08	4.70E-11	2.40E-08	0.00E+00
dichloroethane,1,2	6.16E-03	2E-01		4.22E-08	8.27E-11	2.11E-07	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	5.01E-08	9.80E-11		8.91E-12
trichloroethane,1,1,1	2.58E-02	9E-01		1.77E-07	3.46E-10	1.97E-07	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-03		4.05E-08	7.92E-11	1.35E-05	0.00E+00
trichloroethene	4.01E-02		1.1E-02	2.75E-07	5.38E-10		5.92E-12
Benzene	5.99E-03		2.9E-02	4.11E-08	8.04E-11		2.33E-12
methyl,4-2-pentanone	6.12E-03			4.20E-08	8.21E-11		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	1.56E-07	3.06E-10	1.56E-05	1.56E-11
toluene	6.94E-03	2E+00		4.76E-08	9.31E-11	2.38E-08	0.00E+00
ethylbenzene	1.14E-02	1E+00		7.82E-08	1.53E-10	7.82E-08	0.00E+00
xylenes (total)	2.15E-02	4E+00		1.47E-07	2.89E-10	3.69E-08	0.00E+00
naphthalene	8.20E-02	4E-02		5.62E-07	1.10E-09	1.41E-05	0.00E+00
methnaphthalene,2	7.70E-02			5.28E-07	1.03E-09		0.00E+00
acenaphthene	1.40E-01	6E-01		9.60E-07	1.88E-09	1.60E-06	0.00E+00
dibenzofuran	1.20E-01			8.23E-07	1.61E-09		0.00E+00
fluorene	2.21E-01	4E-01		1.52E-06	2.97E-09	3.79E-06	0.00E+00
phenanthrene	5.47E-01			3.75E-06	7.34E-09		0.00E+00
anthracene	2.75E-01	3E+00		1.89E-06	3.69E-09	6.29E-07	0.00E+00
fluoranthene	7.88E-01	4E-01		5.40E-06	1.06E-08	1.35E-05	0.00E+00
pyrene	6.58E-01	3E-01	4.7E-01	4.51E-06	8.83E-09	1.50E-05	4.15E-09
butylbenzylphthalate	2.29E-01	2E+00		1.57E-06	3.07E-09	7.85E-07	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	3.22E-06	6.29E-09		5.29E-09
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	1.10E-06	2.15E-09	5.49E-05	3.01E-11
chrysene	4.34E-01		2.5E-02	2.98E-06	5.82E-09		1.46E-10
benzo(b)fluoranthene	4.54E-01		8.1E-01	3.11E-06	6.09E-09		4.95E-09
benzo(k)fluoranthene	4.35E-01		3.8E-01	2.98E-06	5.84E-09		2.24E-09
benzo(a)pyrene	4.54E-01		5.8E+00	3.11E-06	6.09E-09		3.53E-09
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	1.92E-06	3.76E-09		5.07E-10
benzo(g,h,i)perylene	2.88E-01		1.3E-01	1.97E-06	3.86E-09		4.95E-10
Gamma-BHC	1.30E-03	3E-04		8.91E-09	1.74E-11	2.97E-05	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	1.30E-08	2.55E-11	4.34E-04	4.33E-10
endosulfan I	5.20E-03			3.57E-08	6.98E-11		0.00E+00
DDE	2.10E-02		3.4E+01	1.44E-07	2.82E-10		9.58E-09
DDD	9.94E-03		2.4E+01	6.82E-08	1.33E-10		3.20E-09
DDT	1.28E-02	5E-04	3.4E-01	8.78E-08	1.72E-10	1.76E-04	5.84E-11
alpha chlordane	3.11E-03	6E-05	1.3E+00	2.13E-08	4.17E-11	3.55E-04	5.43E-11
gamma chlordane	2.94E-03	6E-05	1.3E+00	2.02E-08	3.95E-11	3.36E-04	5.13E-11
arochlor-1242	1.42E-01		7.7E+00	9.74E-07	1.91E-09		1.47E-08
arochlor-1254	6.02E-02		7.7E+00	4.13E-07	8.08E-10		6.22E-09
calcium	1.01E+05			6.93E-01	1.36E-03		0.00E+00
chromium	3.33E+01	2E-02		2.28E-04	4.47E-07	1.14E-02	0.00E+00
lead	3.53E+02			2.42E-03	4.74E-06		0.00E+00
magnesium	5.65E+04			3.87E-01	7.58E-04		0.00E+00
cadmium	1.03E+00	1E-03		7.06E-06	1.38E-08	7.06E-03	0.00E+00
TOTAL						1.99E-02	9.20E-08

Table J-30

Lenz Oil Baseline Risk Assessment

Short-term construction worker/dermal exposure/soil

Area B-unexcavated

Chemicals	Conc. (mg/kg)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	1.03E-02	6E-02		1.84E-07	3.60E-10	3.07E-06	0.00E+00
acetone	7.57E-02	1E+00		1.35E-06	2.65E-09	1.35E-06	0.00E+00
dichloroethane,1,1	3.50E-03	1E+00		6.25E-08	1.22E-10	6.25E-08	0.00E+00
dichloroethene,1,2	6.16E-03	2E-01		1.10E-07	2.15E-10	5.50E-07	0.00E+00
dichloroethane,1,2	7.30E-03		9.1E-02	1.30E-07	2.55E-10		2.32E-11
trichloroethane,1,1,1	2.58E-02	9E-01		4.61E-07	9.02E-10	5.12E-07	0.00E+00
dichloropropene,1,3,T	5.90E-03	3E-03		1.05E-07	2.06E-10	3.51E-05	0.00E+00
trichloroethene	4.01E-02		1.1E-02	7.16E-07	1.40E-09		1.54E-11
Benzene	5.99E-03		2.9E-02	1.07E-07	2.09E-10		6.07E-12
methyl,4-2-pentanone	6.12E-03			1.09E-07	2.14E-10		0.00E+00
tetrachloroethene	2.28E-02	1E-02	5.1E-02	4.07E-07	7.97E-10	4.07E-05	4.06E-11
toluene	6.94E-03	2E+00		1.24E-07	2.43E-10	6.20E-08	0.00E+00
ethylbenzene	1.14E-02	1E+00		2.04E-07	3.98E-10	2.04E-07	0.00E+00
xylenes (total)	2.15E-02	4E+00		3.84E-07	7.51E-10	9.60E-08	0.00E+00
naphthalene	8.20E-02	4E-02		5.86E-07	1.15E-09	1.46E-05	0.00E+00
methnaphthalene,2	7.70E-02			5.50E-07	1.08E-09		0.00E+00
acenaphthene	1.40E-01	6E-01		1.00E-06	1.96E-09	1.67E-06	0.00E+00
dibenzofuran	1.20E-01			8.57E-07	1.68E-09		0.00E+00
fluorene	2.21E-01	4E-01		1.58E-06	3.09E-09	3.95E-06	0.00E+00
phenanthrene	5.47E-01			3.91E-06	7.65E-09		0.00E+00
anthracene	2.75E-01	3E+00		1.96E-06	3.84E-09	6.55E-07	0.00E+00
fluoranthene	7.88E-01	4E-01		5.63E-06	1.10E-08	1.41E-05	0.00E+00
pyrene	6.58E-01	3E-01	4.7E-01	4.70E-06	9.20E-09	1.57E-05	4.32E-09
butylbenzylphthalate	2.29E-01	2E+00		1.64E-06	3.20E-09	8.18E-07	0.00E+00
benzo(a)anthracene	4.69E-01		8.4E-01	3.35E-06	6.56E-09		5.51E-09
bis(2eth.hex.)phthalate	1.60E-01	2E-02	1.4E-02	1.14E-06	2.24E-09	5.71E-05	3.13E-11
chrysene	4.34E-01		2.5E-02	3.10E-06	6.07E-09		1.52E-10
benzo(b)fluoranthene	4.54E-01		8.1E-01	3.24E-06	6.35E-09		5.15E-09
benzo(k)fluoranthene	4.35E-01		3.8E-01	3.11E-06	6.08E-09		2.33E-09
benzo(a)pyrene	4.54E-01		5.8E+00	3.24E-06	6.35E-09		3.68E-08
indeno(1,2,3,c,d)pyrene	2.80E-01		1.4E+00	2.00E-06	3.91E-09		5.28E-09
benzo(g,h,i)perylene	2.88E-01		1.3E-01	2.06E-06	4.03E-09		5.15E-10
Gamma-BHC	1.30E-03	3E-04		9.29E-09	1.82E-11	3.10E-05	0.00E+00
aldrin	1.90E-03	3E-05	1.7E+01	1.36E-08	2.66E-11	4.52E-04	4.51E-10
endosulfan I	5.20E-03			3.71E-08	7.27E-11		0.00E+00
DDE	2.10E-02		3.4E+01	1.50E-07	2.94E-10		9.98E-09
DDD	9.94E-03		2.4E+01	7.10E-08	1.39E-10		3.33E-09
DDT	1.28E-02	5E-04	3.4E-01	9.14E-08	1.79E-10	1.83E-04	6.08E-11
alpha chlordane	3.11E-03	6E-05	1.3E+00	2.22E-08	4.35E-11	3.70E-04	5.65E-11
gamma chlordane	2.94E-03	6E-05	1.3E+00	2.10E-08	4.11E-11	3.50E-04	5.34E-11
arochlor-1242	1.42E-01		7.7E+00	1.01E-06	1.98E-09		1.53E-08
arochlor-1254	6.02E-02		7.7E+00	4.30E-07	8.41E-10		6.48E-09
calcium	1.01E+05			7.21E-02	1.41E-04		0.00E+00
chromium	3.33E+01	2E-02		2.38E-05	4.65E-08	1.19E-03	0.00E+00
lead	3.53E+02			2.52E-04	4.93E-07		0.00E+00
magnesium	5.65E+04			4.04E-02	7.90E-05		0.00E+00
cadmium	1.03E+00	1E-03		7.36E-07	1.44E-09	7.36E-04	0.00E+00
TOTAL						3.50E-03	9.59E-08

Table J-31

Lenz Oil Baseline Risk Assessment

Inhalation/future short-term worker/area B

dispersion model

Chemical	Conc. (mg/m3)	RfD (mg/kg-day)	SF(mg/kg-day)-1	Intake-NC (mg/kg-day)	Intake-CAR (mg/kg-day)	HQ	Risk
methylene chloride	5.82E-03			2.00E-03	3.90E-06		0.00E+00
acetone	5.43E-02			1.86E-02	3.64E-05		0.00E+00
dichloroethane,1,1	8.45E-03			2.90E-03	5.67E-06		0.00E+00
dichloroethane,1,2	3.01E-03			1.03E-03	2.02E-06		0.00E+00
dichloroethane,1,2	5.38E-08		9.10E-02	1.84E-03	3.61E-06		3.28E-07
trichloroethane,1,1,1	1.26E-02			4.32E-03	8.45E-06		0.00E+00
dichloropropane,1,2	1.30E-03	1.00E-03		4.46E-04	8.72E-07	4.46E-01	0.00E+00
trichloroethene	3.48E-02		1.7E-02	1.19E-02	2.33E-05		3.97E-07
tetrachloroethene	9.93E-02		1.8E-03	3.40E-02	6.66E-05		1.20E-07
toluene	6.84E-03	6E-01		2.35E-03	4.59E-06	3.91E-03	0.00E+00
ethylbenzene	4.10E-03	3E-01		1.41E-03	2.75E-06	4.69E-03	0.00E+00
xylenes(total)	9.07E-03			3.11E-03	6.09E-06		0.00E+00
naphthalene	4.00E-02			1.37E-02	2.68E-05		0.00E+00
fluorene	2.31E-03			7.92E-04	1.55E-06		0.00E+00
anthracene	1.25E-04			4.29E-05	8.39E-08		0.00E+00
fluoranthene	1.16E-04			3.98E-05	7.78E-08		0.00E+00
pyrene	5.35E-07		4.9E-01	1.83E-07	3.59E-10		1.76E-10
dichlorobenzidine,3,3	1.00E-06			3.43E-07	6.71E-10		0.00E+00
butylbenzylphthalate	1.16E-03			3.97E-04	7.76E-07		0.00E+00
benzo(a)anthracene	1.09E-03		8.80E-01	3.73E-04	7.31E-07		6.43E-07
bis-(2-ethylhexyl)phthalate	1.06E-03			3.63E-04	7.11E-07		0.00E+00
chrysene	7.33E-06		2.7E-02	2.51E-06	4.92E-09		1.33E-10
benzo(b)fluoranthene	4.31E-01		8.5E-01	1.48E-01	2.89E-04		2.46E-04
benzo(k)fluoranthene	6.71E-02		4.00E-01	2.30E-02	4.51E-05		1.80E-05
benzo(a)pyrene	1.32E-04		6.1E+00	4.53E-05	8.86E-08		5.40E-07
indeno(1,2,3,c,d)pyrene	1.06E-03		1.4E+00	3.63E-04	7.11E-07		9.96E-07
benzo(g,h,i,c,d)perylene	1.06E-03		1.3E-01	3.63E-04	7.11E-07		9.25E-08
gamma-BHC	1.12E-03		1.8E+00	3.85E-04	7.53E-07		1.36E-06
aldrin	8.45E-06		1.7E+01	2.90E-06	5.67E-09		9.64E-08
DDE	1.21E-03			4.14E-04	8.10E-07		0.00E+00
alpha-chlordane	1.58E-03		1.30E+00	5.42E-04	1.06E-06		1.38E-06
gamma-chlordane	1.58E-03		1.30E+00	5.42E-04	1.06E-06		1.38E-06
arochlor-1242	2.00E-04			6.86E-05	1.34E-07		0.00E+00
arochlor-1254	7.55E-05			2.59E-05	5.07E-08		0.00E+00
TOTAL						4.54E-01	2.71E-04

APPENDIX K
ECOLOGICAL DATA TABLES

FIGURE K-1
LENZ OIL CONCEPTUAL SITE MODEL

Media Receiving Contamination	Potential Transport Mechanisms	Exposure		Environmental Receptors	
		Media	Route	Aquatic plants/ animal	Terrestrial plant/ animal
Soil/Ash	►Direct	Soil	Ingestion/ Biouptake Dermal		• •
	►Volatile Emissions	Air	Inhalation Ambient contact		
	►Infiltration	Ground Water	Biouptake (deep rooted plants)		•
	►Ground Water Transport	Surface Water	Ingestion/ Biouptake Dermal Inhalation	• •	• •
	►Overland Surface Water Flow	Sediments	Ingestion/ Biouptake Dermal	• •	• •
	Deposition To Sediments	Biota	<u>Ingestion</u> Plant Prey	• •	• •
	►Deposition				
	►Biotic Uptake				

TABLE K-1
CONTAMINANT CONCENTRATIONS IN DITCH SURFACE WATER ($\mu\text{g/L}$)

Contaminant	Concentration ^a	FWAQC ^b	FWCQC ^c	WFIQC ^d	FC ^e	DW ^f
Pyrene	2	—	—	—	—	—
Xylene	10	—	—	—	—	—
Cadmium	15.2	3.9	1.1	10	—	0.01
Calcium	643,935	—	—	—	—	—
Chromium (total)	64.7	16 (Cr VI)	11 (Cr VI)	50	—	0.06
Silver	5.44	4.1	0.44	50	—	—
Zinc	1,919	120	110	—	—	—

- ^a Confidence Interval Quality Criteria
^b Fresh Water Acute Quality Criteria
^c EPA (1986) Fresh Water Chronic Quality Criteria
^d EPA (1986) Water and Fish Ingestion Quality Criteria
^e EPA (1986) Fish Consumption Only Criteria
^f EPA (1986) Drinking Water Criteria

TABLE K-2
CONTAMINANT CONCENTRATIONS IN DITCH SEDIMENT
(Organic Constituents in µg/kg; Inorganic Constituents in mg/kg)

Contaminant	Concentration	Log(k_{ow})	Sediment Quality Criteria ^{a,b}
<u>Organic Constituents</u>			
Acetone	180	--	--
Xylenes (total)	8.8	--	--
Naphthalene	1,291	3.6	62 ^b
2-Methylnaphthalene	440	--	--
Acenaphthene	1,241	--	4.6 ^b
Dibenzofuran	1,215	--	--
Fluorene	1,744	4.4	--
Phenanthrene	9,245	4.5	7
Anthracene	2,018	4.3	--
Fluoranthene	7,031	5.5	60.8 ^b
Pyrene	5,881	4.9	65.6
Benzo(a)anthracene	3,085	5.6	65.9
Bis(2-ethylhexyl)phthalate	730	4.2	--
Chrysene	2,857	5.6	--
Benzo(b)fluoranthene	2,800	6.6	--
Benzo(k)fluoranthene	2,100	6.8	--
Benzo(a)pyrene	2,382	6.0	4.5 ^b
Indeno(1,2,3,c,d)pyrene	1,132	--	--
Benzo(g,h,i)perylene	1,139	7.0	--
<u>Inorganic Constituents</u>			
Aluminum	14,700	--	--
Calcium	107,732	--	--
Chromium (total)	59.6	2.1	100
Cobalt	31.2	--	50
Lead	253	2.2	50
Selenium	5.7	--	1
Thallium	.95	1.2	--
Zinc	212	2.8	100

a Compiled from Ecology (1991)

b Where applicable, sediment criteria based on mg/kg organic carbon have been converted to a dry weight basis assuming 5 percent of organic carbon content

TABLE K-3
CONTAMINANT CONCENTRATIONS IN GROUNDWATER (in µg/L)

Area	Contaminant	Concentration (High)	1/400 Dilution	FWAQC ^a	FWCQC ^b	WFIQC ^c	FC ^d	Log (K _{ow}) ^e
Area A	1,1 Dichloroethane	28	0.1	—	—	—	—	1.8
Level U	1,2 Dichloroethene	3	0.0	—	—	—	—	—
	Chloroform	14	0.0	28,900	1,240	0.19	15.7	1.9
	Trichloroethene	2	0.0	—	—	—	—	2.4
	Ethylbenzene	370	0.9	32,000	—	1.4	3.28	5.1
	Xylenes (total)	890	2.2	—	—	—	—	—
	Phenanthrene	1	0.0	—	—	—	—	4.5
	Di-n-Butylphthalate	1	0.0	—	—	—	—	3.1
	Fluoranthene	2	0.0	3,960	—	42	54	5.5
Area B	Vinyl Chloride	15	0.0	—	—	2	525	0.6
Level U	Chloroethane	5	0.0	—	—	—	—	1.5
	1,1 Dichloroethene	5	0.0	—	—	—	—	—
	1,1 Dichloroethane	70	0.2	—	—	—	—	1.8
	1,2 Dichloroethene	19	0.5	—	—	—	—	—
	1,1,1 Trichloroethane	120	0.3	—	—	18.4	1.03	2.5
	Trichloroethene	6	0.0	—	—	—	—	2.4
	Di-n-Butylphthalate	1	0.0	—	—	—	—	5.1
Area A	Chloroethane	53	0.1	—	—	—	—	1.5
Level L	Benzene/Hexadecane	10	0.0	5,300	—	0.86	40	2.1
	Toluene	4	0.0	17,500	—	14.3	424	2.2
	Diethylphthalate	1	0.0	—	—	360	1.8	1.4
	Di-n-Butylphthalate	1	0.0	—	—	—	—	5.1
Area B	Di-n-Butylphthalate	1	0.0	—	—	—	—	5.1
Level L								

- a EPA (1986) Fresh Water Acute Quality Criteria
b EPA (1986) Fresh Water Chronic Quality Criteria
c EPA (1986) Water and Fish Ingestion Quality Criteria
d EPA (1986) Fish Consumption Only Criteria
e COE/EPA (1991) Octanol-Water Partitioning Coefficient

APPENDIX B
TECHNICAL MEMORANDUM NO. 1

**TECHNICAL MEMORANDUM NO. 1
DESCRIPTION OF CURRENT SITUATION REPORT
REMEDIAL INVESTIGATION
PHASE I, TASK 1**

**LENZ OIL SERVICE, INC.
LEMONT, ILLINOIS**

REVISION: 1

SUBMITTED BY:

LENZ OIL SETTLING RESPONDENTS

MAY 2, 1991

PREPARED BY:

**ENVIRONMENTAL RESOURCES MANAGEMENT-NORTH CENTRAL, INC.
102 WILMOT ROAD, SUITE 300
DEERFIELD, IL 60015**

ERM PROJECT NO. 0252

TABLE OF CONTENTS

	<u>Page</u>
List of Tables	
List of Figures	
1.0 INTRODUCTION	1-1
2.0 PHYSICAL CHARACTERISTICS OF THE SITE	2-1
2.1 Site Location	2-1
2.2 Site Description	2-1
2.3 Physiography	2-2
2.4 Land Use	2-3
2.5 Site Access	2-3
2.6 Surface Water Hydrology	2-4
2.7 Geology	2-5
2.7.1 Stratigraphy of Southeastern Dupage County	2-5
2.7.2 Stratigraphy of the Lenz Oil Site	2-7
2.7.3 Structural Geology and Regional Fracture Analysis	2-7
2.8 Hydrogeology	2-13
3.0 SITE BACKGROUND	3-1
3.1 History of Ownership	3-1
3.2 History of Waste Transport, Storage, and Disposal	3-1
3.3 History of Response Actions	3-5
3.4 Historical Aerial Photograph Analysis	3-12
3.4.1 1954 Aerial Photograph	3-12
3.4.2 1961 Aerial Photograph	3-13
3.4.3 1967 Aerial Photograph	3-13
3.4.4 1971 Aerial Photograph	3-14
3.4.5 1974 Aerial Photograph	3-14
3.4.6 1981 Aerial Photograph	3-14
3.4.7 1988 Aerial Photograph	3-15

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
4.0 NATURE AND EXTENT OF CONTAMINATION	4-1
4.1 Preliminary Conceptual Site Model	4-1
4.2 Primary Contamination Sources	4-1
4.3 Primary Release Mechanisms	4-3
4.4 Secondary Contamination Sources	4-3
4.5 Secondary Release Mechanisms	4-5
4.6 Migration Pathways	4-5
4.7 Potential Receptors	4-7
4.7.1 Ground Water Users	4-8
4.7.2 Surface Water Users	4-13
4.7.3 Wetlands	4-13
4.7.4 Endangered or Threatened Species	4-14
5.0 CONCLUSIONS AND RECOMMENDATIONS	5-1
REFERENCES	
APPENDICES	
A GEOLOGIC LOGS	
B WELL CONSTRUCTION LOGS	

LIST OF TABLES

<u>Number</u>	<u>Description</u>
2-1	Vertical Joint Orientation
2-2	Water Level Measurements Measurements
3-1	1980-1981 Waste Stream
3-2	Non-Waste Materials Stored On Site
3-3	1984 Waste Stream
3-4	Total Reported Waste Stream Through 5/24/86
3-5	Aerial Photograph Information
4-1	Reported Contaminants in Drums, Tanks, and Tank Trucks
4-2	Reported Contaminants in Surface Impoundments
4-3	Reported Contaminants in On-Site Soil
4-4	Reported Contaminants in Incinerator Ash
4-5	Reported Contaminants in Tent Samples
4-6	Private Well Sampling Parameters
4-7	Reported Contaminants in Private Wells
4-8	Reported Contaminants in Monitoring Wells
4-9	Private Well Data

LIST OF FIGURES

<u>Number</u>	<u>Description</u>
2-1	Location Map
2-2	Base Map
2-3	Land Use Map
2-4	Generalized Stratigraphic Column for the Chicago Area
2-5	Soil Boring/Monitoring Well Location Map
2-6	Stratigraphic Cross Section A-A'
2-7	Stratigraphic Cross Section B-B'
2-8	USGS Vertical Joint and Lineament Orientation Data
2-9	Outcrop Location Map
2-10	ERM Vertical Joint Orientation Data
2-11	Water Table Map, January 29, 1991
2-12	Water Table Map, February 26, 1991
2-13	Water Table Map, March 20, 1991
3-1	Pre-Remediation Site Features Map
3-2	Site Investigation/Remediation Features Map
3-3	Post-Remediation Site Features Map
3-4	Annotated Aerial Photograph, October 7, 1954
3-5	Annotated Aerial Photograph, September 6, 1961
3-6	Annotated Aerial Photograph, September 30, 1967
3-7	Annotated Aerial Photograph, May 14, 1971

LIST OF FIGURES
(Continued)

<u>Number</u>	<u>Description</u>
3-8	Annotated Aerial Photograph, October 10, 1974
3-9	Annotated Aerial Photograph, November 7, 1981
3-10	Annotated Aerial Photograph, April 12, 1988
4-1	Preliminary Conceptual Site Model
4-2	Ground Water Analytical Results
4-3	Private Well Location Map

1.0 INTRODUCTION

This Technical Memorandum describes the results of the background study conducted as part of Phase I, Task 1 of the Lenz Oil Site Remedial Investigation/Feasibility Study (RI/FS). The background study consisted of compiling and analyzing existing data regarding the physical characteristics, history, and nature and extent of contamination at the site. The specific activities that were accomplished during the background study are described in Sections 5.1.1 through 5.1.9 of the Lenz Oil RI/FS Work Plan (ERM-North Central, Inc., 1990).

The background study was conducted to: (1) help determine what additional data are necessary to characterize this site, (2) develop a better conceptual understanding of the site, (3) better define the applicable or relevant and appropriate requirements (ARARs), and (4) narrow the range of remedial alternatives that have been identified. Most of the background study was performed prior to the development of the Lenz Oil RI/FS Work Plan and was used to determine the initial scope of the Lenz Oil Site RI/FS. The results of the initial background study are presented in Sections 2.0 and 3.0 of the Lenz Oil Site RI/FS Work Plan (ERM-North Central, Inc., 1990).

Supplemental background study activities were included in Phase I, Task 1 of the Lenz Oil RI/FS to evaluate the existing data more thoroughly and to better define the scope of Phase I, Task 2 and Phase II, Task 1 activities. Furthermore, these additional background study activities have resulted in a better characterization and conceptual understanding of this site.

Technical Memorandum No. 1 (TM1) is being submitted on behalf of the Lenz Oil Settling Respondents in accordance with Article IX, Part A of the Administrative Order by Consent (USEPA, 1989) and Section 5.1.10 of the Lenz Oil Site RI/FS Work Plan (ERM-North Central, Inc., 1990).

2.0 PHYSICAL CHARACTERISTICS OF THE SITE

2.1 Site Location

The Lenz Oil site is situated northeast of the intersection of Illinois Route 83 and Jeans Road in southeastern DuPage County, Illinois (Figure 2-1). The site is approximately 3.5 miles northeast of the center of Lemont, Illinois and is located in the southeast 1/4 of Section 11, T37N, R11E, of the Sag Bridge 7.5-minute quadrangle.

2.2 Site Description

The Lenz Oil site is bounded by the Atchison, Topeka, and Santa Fe Railroad to the northwest; Illinois Route 83 to the southwest; Jeans Road to the southeast; and a private residence/small business to the northeast. The site is legally described as follows:

Lot 3 of Jacob J. Jeans plat of survey as part of the southeast quarter of Section 11, Township 37 North, Range 11 East of the 3rd principal meridian, in DuPage County, Illinois, according to the Plat thereof recorded October 7, 1950 as document 606585, except the part of Lot 3 lying northeast of a line perpendicular to Jeans Road from a point which is 202.0 feet southwest, as measured along the southeastern line of Lot 3, of the southeastern corner of Lot 3.

ERM-North Central, Inc. (ERM-North Central) retained Patrick Engineering to perform a boundary and topographic survey of the 4.9-acre Lenz Oil site and the area surrounding the site. A base map, illustrating the topography of the site and all pertinent site features, was produced from the survey data (Figure 2-2). A 100-foot grid was established on the site to ensure the accurate location of sample points. As illustrated on Figure 2-2, the site is currently a vacant grassy area containing a radio antenna, several monitoring wells, a fire hydrant, and two underground utility manways.

2.3 Physiography

The Lenz Oil site is located in the Wheaton Morainal Country Subsection of the Great Lakes Section of the Central Lowland Physiographic Province (Willman, 1971). In general, the Wheaton Morainal Country is characterized by physiographic features sculpted by continental glaciers. It contains rough knob and kettle topography, kames, kame terraces, and eskers, all of which are among the youngest Wisconsinan drift deposits. This widespread mantle of glacial drift was deposited over an irregular bedrock erosional surface. The thickness of the drift varies, depending on the nature of the bedrock topography, the glacial history, and the amount of post-glacial erosion.

The physiography of the area immediately surrounding the Lenz Oil site is one of undulating uplands, which have been dissected by well-developed drainage channels and rivers. The uplands are characteristic of the rough-surfaced moraines of the Valparaiso Morainic System, portions of which contain pot-hole lakes and wetland areas. Erosion along the Des Plaines River has removed the glacial deposits along the river pathway, thereby exposing the underlying bedrock in a number of areas.

The Lenz Oil site is located in the flood plain of the Des Plaines River, where the river cuts through the rough knob and kettle topography of the Valparaiso Morainic System. As shown on Figure 2-1, the site is situated at the base of a 75-foot bluff that defines the northern boundary of the Des Plaines River Valley. The river valley is relatively smooth and flat compared to the adjacent moraine deposits. The Des Plaines River is approximately 600 feet southeast of the site, and the Chicago Sanitary and Ship Canal is an additional 800 feet beyond the Des Plaines River. On the north side of the Des Plaines River, the regional slope is toward the southeast (i.e., toward the river); however, the site topography has been modified, and part of the site now slopes toward the northwest, where a small ephemeral drainage ditch is situated. The elevation of the site is approximately 600 feet above sea level.

2.4 Land Use

The Lenz Oil site and most of the surrounding area are either idle and undeveloped or used for commercial, light industrial, or residential purposes (Figure 2-3). The site itself is currently vacant and idle. Immediately northwest of the site, the Atchison, Topeka, and Sante Fe Railroad operates an active railroad line. The land northwest of the railroad is primarily wooded open land with a few isolated residential and commercial properties. The areas immediately northeast and southeast of the Lenz Oil site are used for residential purposes; however, large portions of the land are undeveloped and idle. Further east of the site, the land is utilized for commercial and light industrial purposes (i.e., auto wrecking, fire wood cutting, and paving). The property southwest of the site is also used for commercial purposes (i.e., a large auto wrecking facility). The land south of the Lenz Oil site, between the Des Plaines River and the Chicago Sanitary and Ship Canal, consists of wetlands and idle woodland.

There are several notable land use features outside the immediate vicinity of the Lenz Oil site. The Argonne National Laboratory reservation is located approximately 1,400 feet northwest of the site. The southern border of the community of Downers Grove is situated approximately 3,500 feet north of the site. Much of the area southeast of the site, across the Des Plaines River and the Chicago Sanitary and Ship Canal, consists of forest preserve and wetlands. Finally, there are several large industrial complexes situated along the Des Plaines River, both upstream and downstream of the Lenz Oil site.

2.5 Site Access

Access to the Lenz Oil site is controlled by a combination of wire, chain-link, and wooden fencing. As shown on Figure 2-2, the fencing is continuous along the southeastern half of the site, but gaps in the fencing occur in the northern and western corners of the site. Two gates

in the fencing along Jeans Road, which are secured with chains and locks, serve as the primary entry points to the site. No on-site personnel control access to the property.

2.6 Surface Water Hydrology

The Lenz Oil site is located within the Des Plaines River subbasin of the Mississippi River watershed. It is situated within the Des Plaines River Valley, which contains the Chicago Sanitary and Ship Canal, the Illinois and Michigan Canal, and the Des Plaines River/Diversion Channel (Figure 2-1). The Des Plaines River and the Chicago Sanitary and Ship Canal merge into a single river approximately three miles north of Joliet. The Calumet Sag Channel, which is an extension of the Little Calumet River, discharges to the Chicago Sanitary and Ship Canal, approximately 3/4 miles southwest of the Lenz Oil site (Figure 2-1). All of surface water in the Des Plaines River Valley flows to the southwest and eventually empties into the Mississippi River. The Des Plaines River is approximately 200 feet wide at its closest approach to the Lenz Oil site; whereas the adjacent Chicago Sanitary and Ship Canal is approximately 150 feet wide at the same location. According to the Illinois State Water Survey (ISWS), the discharge of the Des Plaines River in the vicinity of the site (i.e., the Riverside gage) ranged from 147 cubic feet per second (cfs) to 3,720 cfs in 1989. The maximum flow recorded in Des Plaines River since installation of the Riverside gage in 1943 is 9,770 cfs. Based on measurements taken at the Romeoville gage, discharge in the Chicago Sanitary and Ship Canal ranged from 1,790 cfs to 12,800 cfs in 1989. The maximum flow recorded in the Chicago Sanitary and Ship Canal since 1974 is 16,300 cfs.

Surface water runoff from the Lenz Oil site and the immediate vicinity of the site either infiltrates the soil or discharges to the Des Plaines River. There are no permanent storm sewer or draining systems to direct surface water runoff from the site. However, a small ephemeral drainage ditch, situated along the northwest border of the site, is the recipient of surface water runoff from the northern half of the site and from the area northwest of the site. This drainage

ditch apparently meanders through the auto wrecking facility southwest of the site and eventually discharges to the Des Plaines River. Although pot-hole lakes are common in the upland areas surrounding the site and several wetland areas are located in the Des Plaines River Valley, no permanent surface water bodies are situated within the bounds of the Lenz Oil site.

2.7 Geology

2.7.1 Stratigraphy of Southeastern DuPage County

The geology of southeastern DuPage County consists of a thick sequence of Silurian bedrock overlain by Quaternary glacial drift and alluvial deposits. A generalized stratigraphic column for the Chicago area is shown on Figure 2-4. The uppermost bedrock in the study area is Silurian dolomite of the Racine Formation, which is the uppermost unit in the Niagaran Series (Willman, 1971). The Racine Formation is a light-gray, pure to silty, sometimes cherty, well-bedded dolomite. The formation crops out: (1) along the northern bluffs of the Des Plaines River Valley, (2) along the banks of the Des Plaines River and the Chicago Sanitary and Ship Canal, (3) on valley floors of large tributary streams, and (4) in quarries in the vicinity of the site.

Underlying the Racine Formation are the Sugar Run and Joliet Formations, which are also part of the Niagaran Series, and the Kankakee and Elwood Formations, which are part of the Alexandrian Series (Willman, 1971). The lithologies of these formations are similar to the overlying Racine Formation. The thickness of the Silurian dolomite varies across southeastern DuPage County because of differential pre-glacial and post-glacial erosion of the bedrock surface. A test boring drilled in the Palos Forest Preserve, which is across the Des Plaines River Valley from the Lenz Oil site, encountered 171 feet of Silurian dolomite before penetrating the underlying bedrock unit (Nicholas and Healy, 1988).

The bedrock surface in southeastern DuPage County is an irregular plain, most of which was shaped by Pleistocene glacial erosion (Willman, et al., 1975). Data from outcrops and borings show that the bedrock has a gently rolling, dissected surface with a well-integrated drainage pattern. A number of deep (up to 150 feet) paleo-river valleys were cut into the underlying bedrock during a major deglaciation event in the area. According to Zeizel and others (1962), the orientation of the paleo-river valleys in DuPage County is controlled by major joints sets in the underlying bedrock. Furthermore, preliminary interpretation of recently compiled seismic-refraction data collected by Nicholas and Healy (1988) suggests that the bedrock surface is a former karst plain. Outcrop and boring data support the karst plain interpretation by documenting the presence of a weathered zone, up to 5 feet thick, at the top of the Silurian dolomite.

Unconsolidated deposits of Quaternary age overlie the Silurian bedrock throughout southeastern DuPage County, except where it has been removed by man or erosion and the underlying bedrock is exposed (Willman, 1971). Most of the unconsolidated deposits consist of Pleistocene glacial drift. The glacial drift is generally of Wisconsinan age and consists primarily of the Wadsworth Till Member of the Wedron Formation, which is a silty and pebbly clay till with local beds of sandy to gravelly moraine deposits (Willman and Lineback, 1970). The Wadsworth Till Member is widespread in upland areas, but has been removed by erosion from the Des Plaines River Valley. A thin veneer of Holocene alluvium is present along portions of the Des Plaines River Valley. The alluvium consists of valley-train deposits of the Mackinaw Member of the Henry Formation (Willman and Lineback, 1970). The Mackinaw Member is a poorly sorted, silty sand with local deposits of sandy gravel.

2.7.2 Stratigraphy of the Lenz Oil Site

Eleven stratigraphic borings have been drilled during previous environmental investigations of the Lenz Oil site. The approximate locations of these borings are shown in Figure 2-5, and copies of the original geologic and well construction logs are included as Appendices A and B, respectively. As shown on Figures 2-6 and 2-7, the Racine Dolomite was encountered at the site at depths ranging from 6.0 to 24.5 feet below ground surface. The bedrock is rubbly at the top and fractured throughout the encountered interval. In general, the bedrock surface becomes shallower toward the southeast; however, on a small scale, the bedrock surface is extremely irregular.

The dolomitic bedrock is directly overlain by a bed of silty dolomitic gravel with varying amounts of sand and clay. This deposit was interpreted as glacial outwash by the IEPA physical measurement unit, but it is more likely a layer of weathered dolomite that has escaped erosion and redeposition. A bed of silt, containing variable amounts of sand, clay, and gravel, overlies the weathered dolomite. These poorly sorted deposits are either valley train sediments of the Mackinaw Member of the Henry Formation or, more likely, alluvial deposits associated with the Des Plaines River.

2.7.3 Structural Geology and Regional Fracture Analysis

All of northern Illinois, including the Lenz Oil site, is located within the Central Stable Region tectonic province of the North American continent. The region is characterized by a sequence of southward-thickening sedimentary strata overlying Precambrian basement rocks, which were subject to a series of vertical crustal movements that formed broad basins and arches during the Paleozoic and early Mesozoic time periods. The arches and basins subsequently have been modified by local folding and faulting activity. The major geologic structures in the vicinity of the Lenz Oil site include:

- o Illinois Basin - an oval-shaped basin with a depocenter located south of the Lenz Oil site in South-Central Illinois. Strata in the basin rises gently toward the Kankakee Arch in the northeast.
- o Kankakee Arch - a northwest-southeast trending extension of the Wisconsin Arch. The Arch is a result of crustal uplift.
- o Sandwich Fault Zone - a northwest-southeast trending vertical fault, approximately 85 miles in length. The fault has about 900 feet of vertical displacement, and all movement along the fault is post-Silurian and pre-Pleistocene.

The Lenz Oil site is located on the crest of the Kankakee Arch, near the northeastern edge of the Illinois Basin. The southeastern extent of the Sandwich Fault Zone is approximately 23 miles southwest of the Lenz Oil site at its closest approach. Although all of these structural features are presently inactive, past activity has strongly influenced the local character of bedrock. For example, in the vicinity of the Lenz Oil site, the Silurian strata dip slightly to the east and southeast because of the eastward plunge of the Kankakee Arch. Furthermore, tensile stress from subsidence of the Michigan and Illinois Basins and uplift of the Wisconsin and Kankakee Arches has caused jointing in the brittle Silurian dolomite (Foote, 1982). Joints in the dolomite occur in three mutually orthogonal sets, two of which are vertical and one of which is horizontal (Nicholas and Healy, 1988). The vertical sets of joints were caused by structural deformation, as noted above; whereas the horizontal set was formed as a result of carbonate dissolution along bedding planes. According to Zeizel and others (1962), the orientation of bedrock valleys in DuPage County is controlled by these major joint sets.

The U.S. Geological Survey conducted research into the orientation and spacing of joint sets in the Silurian dolomite as part of their study to determine the geologic and hydrologic factors that

control migration of tritium from a closed, low-level radioactive waste disposal site, located approximately 1.5 miles southeast of the Lenz Oil site. The joint analyses included lineament mapping, bedrock surface mapping, and studies of joint orientations exposed in outcrops of the Silurian dolomite (Nicholas and Healy, 1988). The orientations of 156 vertical joints, measured in two quarries were plotted on a rose diagram by plotting 1-unit length per joint and grouping the joints into 5-degree sectors (Figure 2-8). A total of 106 linear structural features were mapped on aerial photographs of the 25-square-mile area surrounding the low-level radioactive waste disposal site and plotted on a rose diagram by using 1-unit length per 100 feet of lineament length and grouping the lineaments into 5-degree sectors (Figure 2-8). The rose diagram of the vertical joint orientations shows two orthogonal sets of joints: one set of joints with an azimuth of 40 degrees, and the other set with an azimuth of 130 degrees. The rose diagram of the lineaments reveals three major sets: two of which correspond to the vertical joint sets and one set, which is oriented at 20 degrees azimuth and has no apparent analogy among the vertical joint sets.

Zeizel and others (1962) and Foote (1982) have shown that the frequency and aperture of vertical joints in the vicinity of the Lenz Oil site decrease with depth below the bedrock surface. This interpretation is based on the assumption that private wells are generally set opposite the most productive portion of an aquifer, which in the case of the Silurian dolomite would be the most highly fractured portion of the aquifer. By plotting well frequency versus depth of penetration into the Silurian dolomite, Zeizel and others (1962) concluded that the upper 60 feet of the dolomite is the most productive portion of the aquifer. Although unconfirmed by direct field measurements, significant fractures probably extend at least 60 feet into the dolomite; however, this conclusion is preliminary and may not accurately describe the bedrock below the Lenz Oil site.

Because Nicholas and Healy (1988) collected their lineament and vertical joint orientation data from an area that included the Lenz Oil site, data from their study are considered applicable to

the Lenz Oil investigation. However, as proposed in Section 5.1.9 of the Lenz Oil RI/FS Work Plan (ERM-North Central, Inc., 1990), ERM-North Central conducted a regional fracture analysis to independently verify the findings of previous investigations. This field investigation was conducted between March 16 and April 7, 1991.

ERM-North Central performed reconnaissance of the area within approximately 1.5 miles of the site to locate outcrops of the Silurian dolomite to be used for the collection of fracture data. The Des Plaines River Channel, the Chicago Sanitary and Ship Canal, the Illinois and Michigan Canal, and the Calumet Sag Channel were all investigated for bedrock exposures. Silurian dolomite outcrops were observed in many areas along these canals and channels, but many of the outcrops appeared to have been disturbed by construction activities. The best undisturbed bedrock exposures were found at or near the Sag Quarries Recreation Area in the Palos Forest Preserve (T37N, R11E, Sections 13 and 14). This area contains abandoned quarries and extensive bedding plane exposures of the Silurian dolomite. The seven outcrops, selected for collection of joint data, are shown on Figure 2-9.

The distribution of the 278 joint orientation measurements, which were collected from the seven outcrops, are shown on Table 2-1 and Figure 2-10. The orientations of the joints were plotted on rose diagrams by grouping the joints into 5-degree sectors and plotting 1-unit length per joint (Figure 2-10). The rose diagram of all the joint measurements (Figure 2-10A) shows three discrete sets of joints: (1) a primary set exhibiting an average azimuth of 132°, (2) a secondary set exhibiting an average azimuth of 47°, and (3) a tertiary set exhibiting an average azimuth of 25°. Although these results closely approximate the results of Nicholas and Healy (1988), ERM-North Central's data show a bi-modal distribution of the primary joint set orientations (Figure 2-10A). The joint set exhibits two prominent orientation nodes, one at 115° to 125° and the other at 130° to 140°.

Because the bi-modal distribution may be a result of construction activities along the Calumet Sag Channel, ERM-North Central separated these data into two groups: measurements collected near the channel (i.e., Outcrops #1 through #5) and measurements collected away from the channel (i.e., Outcrops #6 and #7). Measurement data from each group were tabulated (Table 2-1) and plotted on rose diagrams (Figures 2-10B and 2-10C). The primary joint set measurements taken from outcrops near the channel (Figure 2-10B) show the same bi-modal distribution as the entire data set (Figure 2-10A). However, the primary joint set data collected from the outcrops away from the channel form a single node at 130° to 140° (Figure 2-10C). This suggests that joints exhibiting an orientation of 115° to 125° are only found along the Calumet Sag Channel and, thus, may be an artifact of blasting and construction along the channel and not representative of natural conditions.

The joint orientation data from outcrops away from the channel (Figure 2-10C) are the least likely to have been affected by man-made causes and, thus, are considered the most representative of regional vertical joint orientation patterns. These data suggest the presence of: (1) a primary joint set with an average azimuth of 135°, (2) a secondary joint set oriented at right angles to the primary joint set with an average azimuth of 45°, and (3) a minor tertiary joint set with an average azimuth of 20°. These results are very similar to the vertical joint orientation results reported by Nicholas and Healy (1988).

Because no information regarding the spacing and width of the vertical joints was found in the published literature, ERM-North Central collected these measurements from the seven outcrops described above. The width (or aperture) of the primary and secondary joints varies from tightly closed to approximately 4 inches. The exposed joints are generally wider than the unexposed joints, due to weathering. The spacing ranges from 0.5 to 36 inches and averages approximately 12 inches for the primary joints and from 8 to 24 inches and averages approximately 14 inches for the secondary joints. The length and depth of the joints could not be accurately discerned

because of limited bedrock exposure. Where present, the tertiary joints are prominent and laterally extensive, but they were infrequently observed.

According to Nicholas and Healy (1988), horizontal joints along bedding planes are evident in outcrops and from interpretation of borehole geophysical logs from borings drilled at the low-level radioactive waste disposal site. Outcrops along the northern side of the Des Plaines River Valley display prominent horizontal joints, hundreds of feet long. Many of the joints are weathered, and some are several inches wide. Correlation of horizontal joints between borings at the low-level radioactive waste disposal site is excellent, suggesting the joints are continuous for at least 1,600 feet in the subsurface (Nicholas and Healy, 1988). The apertures of subsurface horizontal joints were measured to be as wide as 2 feet. There is also evidence that many horizontal joints have been infilled with sediment ranging in size from clay to sand.

Nicholas and Healy (1988) have classified all horizontal joints into two groups, subregional and regional. Joints that are areally extensive are considered regional joints; whereas joints that are located in bedrock highs and are truncated at the bedrock surface are classified as subregional joints. Subregional joints are more commonly filled with glacial sediment than regional joints. Based on their interpretation of borehole geophysical logs, Nicholas and Healy (1988) have identified major regional joints at elevations of approximately 415, 440, 525, 550, and 565 feet above sea level.

Based on the geological data collected by the IEPA and its contractors, the bedrock surface below the Lenz Oil site occurs at elevations ranging from approximately 582 to 597 feet above mean sea level. This corresponds to approximately 15 feet of bedrock in which horizontal joints would be discontinuous. Therefore, subregional joints are expected to be encountered at elevations above approximately 582 feet, and regional joints are expected below that elevation. The uppermost regional joint reported by Nicholas and Healy (1988) occurred at an elevation

of 565 feet, which may be encountered in some of the deep monitoring well borings drilled during Phase I, Task 2 of the Lenz Oil RI/FS.

2.8 Hydrogeology

The regional hydrogeology of the area around the Lenz Oil site has been described by a number of authors, including Zeizel and others (1962), Walker (1964), Kraatz (1964), Gibb (1965), Sherman (1968), Smith (1946), Storm (1946), Olimpoi (1984), and Nicholas and Healy (1988). The regional hydrogeological information presented in this section is a summary of these previous reports. The hydrostratigraphic units used in this report are those of Zeizel and others (1962). Hydrostratigraphic units are geologic units, which on the basis of character, origin, stratigraphic position, and water-bearing properties, act as distinct hydraulic systems. From top to bottom, the hydrostratigraphic units defined in the vicinity of the Lenz Oil site are: (1) glacial drift aquifers, (2) the Silurian dolomite aquifer, (3) the Maquoketa Formation aquiclude, (4) the Cambrian-Ordovician aquifer, (5) the Eau Claire Formation aquiclude, and (6) the Mt. Simon aquifer.

The glacial drift and Silurian dolomite aquifers are hydraulically separated from the underlying Cambrian-Ordovician aquifer by the relatively impermeable shales of the intervening Maquoketa Formation. The Cambrian-Ordovician aquifer is further separated from the deeper Mt. Simon aquifer by the intervening impermeable beds of the Eau Claire Formation. A review of well logs from private wells, located within a two-mile radius of the Lenz Oil site, has shown that the Cambrian-Ordovician and the Mt. Simon aquifers are not utilized within the vicinity of the site. The Cambrian-Ordovician and the Mt. Simon aquifers are not considered pertinent to this investigation because of their lack of a receptor population and because they are isolated from the shallow glacial drift and Silurian dolomite aquifers by up to 200 feet of Maquoketa shales.

The aquifers pertinent to the investigation of the Lenz Oil site are the shallow glacial drift and the Silurian dolomite aquifers. The glacial drift aquifers consist of relatively clean, coarse-texture deposits of sand and gravel that occur erratically throughout the glacial drift. Three categories of glacial drift aquifers are recognized in DuPage County: (1) surficial, (2) interbedded, and (3) basal. Surficial glacial drift aquifers appear just below the land surface and consist of sand and gravel deposits of glacial outwash origin. These deposits are generally concentrated in the valleys of the major drainageways in the area. Because these deposits are not laterally extensive, few producing wells are completed in surficial glacial drift aquifers.

Interbedded glacial drift aquifers are deposits of sand and gravel, which occur as lenticular or sheet-like deposits, erratically distributed throughout the glacial drift. The sand and gravel beds are generally interbedded with fine-grained glacial till. Although numerous, these interbedded sand and gravel deposits are generally too thin and/or too discontinuous to yield producible volumes of water. The basal glacial drift aquifers consist of sand and gravel deposits at the base of the glacial drift, directly above the Silurian dolomite. These deposits are also extremely variable in terms of thickness and lateral continuity. Although the basal drift aquifers have relatively high permeabilities and produce sufficient volumes of water, they are generally bypassed in favor of completing the well in the underlying dolomite. Although glacial drift aquifers exceeding 40 feet in thickness are present within a two-mile radius of the Lenz Oil site, a review of private well logs in that area has demonstrated that few private drinking water wells are completed in the glacial drift aquifers.

The Silurian dolomite aquifer include rocks of the Niagaran and Alexandrian series. The depth to the top of the Silurian dolomite aquifer (and consequently the thickness of the Silurian dolomite aquifer) varies widely over short distances because of the irregular nature of the bedrock surface. According to an aquifer thickness map by Zeizel and others (1962), the thickness of the Silurian dolomite aquifer is between 150 and 200 feet thick below the Lenz Oil site.

Because the Silurian dolomite aquifer has a crystalline matrix rather than a granular matrix, ground water is primarily stored in secondary openings in the dolomite and moves through a complex network of these secondary openings. The primary porosity of the dolomite (i.e., microscopic joints and small pore spaces in the crystalline matrix of the dolomite) is extremely low and is considered insignificant in terms of ground water flow in this aquifer (Zeizel and others, 1962; Nicholas and Healy, 1988). However, primary porosity may represent a relatively large portion of the storage capacity of the aquifer. Most of the porosity and permeability in the Silurian dolomite aquifer has a secondary origin (i.e, it was formed after the deposition and consolidation of the rock). The most numerous types of secondary openings are joints and fractures that were produced in the dolomite by deformation forces and later enlarged by dissolution (Zeizel and others, 1962). According to Nicholas and Healy (1988), most ground water flow in the dolomite occurs in large joints, especially horizontal joints. However, the total void space represented by these fractures is relatively small compared with the total volume of the rock unit.

Both Nicholas and Healy (1988) and Zeizel and others (1962) report that the weathered zone at the top of the Silurian dolomite and the uppermost horizontal joints within the dolomite are the major conduits for ground water flow in the aquifer. Joints that have been enlarged by solution activity form the best conduits for migration of ground water. Surface and subsurface investigations of the dolomite show that, in general, enlargement of joints by solution activity has been greatest in the upper portion of the bedrock. Consequently, most wells in the vicinity of the Lenz Oil site are completed in the upper 60 feet of the Silurian dolomite aquifer. Below this depth, the unit has much less secondary porosity and a significantly reduced transmissivity. According to Zeizel and others (1962), the Silurian dolomite aquifer has an extensive network of interconnected joints, fractures, and solution cavities. The basis for this conclusion is: (1) the reliability of the dolomite as a source of ground water, (2) the high yields of wells drilled into the dolomite, and (3) the relatively uniform piezometric surface of shallow ground water in the dolomite. Nicholas and Healy (1988) determined that horizontal joints below an elevation

of approximately 570 feet form a regional ground water flow system that extends throughout the Palos Forest Preserve, which is located across the Des Plaines River Valley from the site. It is likely that the same set of horizontal joints extends below the Des Plaines River Valley and underlies the Lenz Oil site.

Vertical joints in the Silurian dolomite aquifer result in an areal anisotropic transmissivity in the aquifer. This conclusion was drawn by Nicholas and Healy (1988) after interpreting aquifer test data from a ground water study at the Argonne National Laboratory site by using the Papadopoulos (1965) solution for anisotropic transmissivity. However, Nicholas and Healy (1988) further concluded that, because the location of individual vertical joints and joint sets was not known for their study area, the effect of vertical joints on ground water flow could not be assessed.

Stratigraphic and water level data collected during previous investigations of the Lenz Oil site show that the aquifer immediately below the site is composed of unconsolidated sand and gravel deposits of alluvial origin and Silurian dolomite. These two units are hydraulically interconnected via the intervening zone of weathered bedrock and a network of interconnected vertical and horizontal joints.

The aquifer is unconfined, and flow is controlled principally by topography. Topographic highs are usually areas of ground water recharge; and conversely, topographic lows are usually areas of ground water discharge. Water level data collected by Nicholas and Healy (1988) from the Palos Forest Preserve clearly demonstrate that ground water flows from the upland areas toward the Des Plaines River Valley. Static water level data from geologic logs of private wells within a two-mile radius of the Lenz Oil site further support the conclusion that ground water flow in the Silurian dolomite aquifer is principally controlled by topography.

Water level measurements were collected from the network of monitoring wells at the Lenz Oil site by the Illinois Environmental Protection Agency (IEPA) on June 4, 1986, November 17, 1986, January 6, 1988, and March 2, 1988 (Table 2-2). Of these four rounds of water level measurements, three rounds show that shallow ground water flows toward the southeast and northeast, and that monitoring wells in cluster G-101 are upgradient of the site. An anomalously high water level was recorded for cluster G-105 during the January 6, 1988 round of measurements, which indicated that ground water was mounded around location G-105, and flow was radial from the site. If the water level measurement from G-105 is eliminated from the January 6, 1988 data set, the resulting ground water flow direction is consistent with the other rounds of water level measurements.

ERM-North Central collected three rounds of water level measurements from the Lenz Oil monitoring wells on January 29, 1991, February 26, 1991, and March 20, 1991, respectively, these measurements, which are shown in Table 2-2, indicate that shallow ground water flow is toward the south, southeast, east, and northeast. As illustrated on the water table maps (Figures 2-9, 2-10, and 2-11) developed from the monthly water level data, the direction of ground water flow appears to vary significantly over time. Some of the variability may be related to changes in the set of monitoring wells from which data were collected. For example, because the shallow well at G-104 was frozen during the January 29, 1991 round of measurements, data from the deep well, which is only 5 feet deeper than the shallow well, was plotted with the shallow wells. Furthermore, water level measurements from three new wells (i.e., MW-01S, MW-04S, and MW-05S) were added to the March data set. Although the water level elevation data sets are not the same, each set indicates shallow ground water below the site flows to the south, southeast, east, and northeast. Final interpretations regarding water flow will be reserved until several rounds of water level measurements are collected from the complete Phase I, Task 2 monitoring well network.

Based on the regional topography and hydrogeology, the uplands northwest of the site are the primary recharge areas for shallow ground water below the site, and the Des Plaines River is probably the discharge area for shallow ground water flowing below the site. The horizontal gradient in the shallow aquifer, as measured from monitoring wells at the Lenz Oil site, is approximately 0.003. The potentiometric head measured in monitoring wells that straddle the water table is 0.17 to 2.62 feet higher than the head measured in monitoring wells screened several feet below the water table. These measurements indicate a downward vertical gradient of 0.013 to 0.444 and a potential for recharge from the water table to the base of the aquifer. Although it is likely that seasonal variations in the stage of the Des Plaines River affects the ground water flow rate below the Lenz Oil site, this has not yet been confirmed by seasonal water level measurements.

Nicholas and Shapiro (1986) conducted a preliminary hydraulic characterization of the Silurian dolomite aquifer beneath the low-level radioactive waste disposal site by using single-hole packer tests at 10-foot intervals in boreholes at their site. To characterize the hydraulic conductivity of the solution-enlarged joint sets, they assumed that each joint is hydraulically analogous to an infinite confined aquifer that is bounded above and below by an impervious dolomite matrix. The uppermost joint set did not fit this assumption because it is hydraulically interconnected with the weathered bedrock zone at the drift-dolomite contact and thus responded like an unconfined aquifer. Estimated values of the hydraulic conductivity for the joint sets range from 2.0×10^{-3} to 1.0×10^{-2} feet/second. The hydraulic conductivity of dolomite contains secondary porosity features, which are less well connected than the joint sets, is approximately 3.0×10^{-5} feet/second. The hydraulic conductivity of the dolomite matrix, if it contained only primary porosity, is estimated to be considerably less than 3.0×10^{-5} feet/second.

3.0 SITE BACKGROUND

3.1 History of Ownership

The following is a chronological summary of the ownership history of the Lenz Oil Service, Inc. property, located at Route 1, Lemont, Illinois 60439. The legal description of this property is presented in Section 2.2 of this Technical Memorandum.

- o 1960 to 1980**
Owner: Lenz Oil Service, Inc.
President: Winston Lenz

- o 1980 - present**
Owner: Lenz Oil Service, Inc.
President: Charles Russell

3.2 History of Waste Transport, Storage, and Disposal

Winston Lenz of Hinsdale, Illinois began operating Lenz Oil Service, Inc. in April 1961. The business originally collected waste oils from local service stations and other small businesses; temporarily stored the waste oils in tanks located at the Lenz Oil Service, Inc. facility; and then shipped the waste oils to local recycling facilities. It also supplied oils and construction materials for roadwork projects. In 1980, Charles Russell purchased the Lenz Oil Service, Inc. stock and took over the operation of the facility. Sometime prior to December 1980, the waste oil collection, storage, and transport operation was expanded to include waste solvents. This portion of the operation involved: (1) collecting spent solvents from local commercial and industrial facilities, (2) transporting the waste solvents in tank trucks licensed for hauling special

waste, (3) temporarily storing the solvents in permanent tanks at the Lenz Oil Service, Inc. facility, and (4) transporting the waste solvents to a local recycling facility.

The waste transport, storage, and disposal activities conducted at the Lenz Oil Service, Inc. facility are not documented in regulatory files for the time period between April 1961 and October 1980. Based on the aerial photograph analysis, which is described in further detail in Section 3.4, the on-site storage capacity for waste oils and spent solvents expanded considerably from 1961 through 1981. No further expansion occurred after 1981. Records describing the types and quantities of waste oils and solvents handled by the Lenz Oil Service, Inc. facility during 1980 and 1981, which are probably the peak years of operation for the facility, are summarized on Table 3-1. Non-waste materials that were stored at the site during 1980 and 1981 are summarized on Table 3-2. These records document the relatively small volume of waste solvents handled by Lenz Oil Service, Inc. compared to the volume of waste oils handled by the facility. Although the waste oils included transformer oil (which may have contained PCBs), the oils were not tested or segregated at the Lenz Oil facility. These mixed waste oils were shipped via tanker truck to a local waste oil recycler on a weekly basis. Spent solvents were allegedly tested by the generator prior to collection by Lenz Oil Service, Inc. According to a letter from Charles Russell to IEPA, the spent solvents were shipped out to a recycler as soon as they were received. However, it is unclear whether or not the solvents were temporarily stored at the Lenz Oil Service, Inc. facility and whether or not the solvents were mixed.

IEPA began keeping records of the waste stream handled at the Lenz Oil Service, Inc. facility sometime after 1983. The 1984 waste stream of the Lenz Oil Service, Inc. facility is summarized on Table 3-3. This summary, which is based on an IEPA report, suggests that the types of wastes accepted by the Lenz Oil Service, Inc. facility were the same as those accepted in 1980 and 1981, but that the volume of waste handled in 1984 was approximately 50 percent less than the volume handled in 1980 and 1981. IEPA used waste manifest records to calculate the approximate total volume of waste transported to and from the Lenz Oil Service, Inc. facility

between the time that manifest records were first required and May 24, 1986, which is after the Lenz Oil Service, Inc. facility ceased operation. A summary of the total waste stream for the Lenz Oil Site during that period is presented on Table 3-4.

According to the IEPA (1985), Lenz Oil Service, Inc. ceased to operate in November 1985. In April 1986, Charles Russell filed for bankruptcy and abandoned the facility completely (IEPA, 1985). At the time the facility was abandoned, the following features were located on the site: a wood-frame office building, a concrete-block maintenance building, a concrete parking shed, a metal structure, two monitoring wells (OW-1 and OW-2), a number of aboveground and underground tanks, several tank trucks, a former surface impoundment area, and a cinder pile (Figure 3-1). A fence with two access gates along Jeans Road enclosed the active portion of the facility. The following storage vessels were located at the Lenz Oil Service, Inc. facility in early 1985:

- o Three high-capacity (30,000- to 80,000-gallon) underground, unlined, concrete storage tanks.
- o Fourteen (14) low- to moderate-capacity aboveground or partially buried steel tanks.
- o Six low-capacity underground steel tanks.
- o Nine tanker trucks with a total capacity of over 30,000 gallons.
- o A drum storage area containing approximately 200 drums.
- o Three surface impoundments constructed of porous cinder-type material that were used for hazardous waste storage.

Beginning in 1980, Lenz Oil Service, Inc. attempted to acquire the necessary permits required to operate a waste oil and spent solvent storage and transfer facility in the State of Illinois. In response to an IEPA inspection of the facility on October 2, 1980, and the subsequent notification that the facility was operating without the required permits, Lenz Oil Service, Inc. applied for a permit to operate a waste management site at their facility. The IEPA issued the necessary permit to operate a storage and transfer facility for waste oils and solvents on July 5, 1981. Because of reported ground water contamination at the site, special conditions in the IEPA permit required Lenz Oil Service, Inc. to assess the extent of ground water contamination caused by oils and grease at the site and submit a plan to: (1) limit further degradation, and (2) upgrade the quality of ground water in the area (IEPA, 1981). Although Lenz Oil Service, Inc. installed two monitoring wells on the site, there is no evidence indicating that a ground water contamination study was conducted or that ground water remediation activities were undertaken.

On November 19, 1980, Lenz Oil Service, Inc. submitted an application to the USEPA for a RCRA Part A Permit to store hazardous material in tanks at their facility. In December 1982, USEPA issued a Consent Agreement and Compliance Order stating that Lenz Oil Service, Inc. was operating their facility without an interim status permit. The site continued to operate and was required to obtain the appropriate hazardous waste permits. During November of 1984, Lenz Oil quit accepting hazardous waste (i.e., spent solvents); and on November 13, 1984, they requested the withdrawal of the facility's Part A Permit, stating that the site no longer handled hazardous waste. On February 5, 1985, Noble and Associates, on behalf of Lenz Oil Service, Inc., submitted a closure plan for that portion of the facility (Tank #1) that handled hazardous waste. IEPA confirmed that solvents were no longer being handled by the facility on February 6, 1985; and on July 22, 1985, IEPA approved a partial closure plan for Tank #1. However, the tank was not closed before the facility ceased operations.

After numerous permit violations involving: (1) manifest infractions, (2) inadequate waste handling practices, and (3) reported releases of hazardous waste to local ground water and

surface water systems, the IEPA referred a law suit to the Illinois Attorney General's Office alleging mismanagement of hazardous waste at the Lenz Oil Service, Inc. facility. In May 1985, a complaint was filed in the Circuit Court of DuPage County, Illinois against Lenz Oil Service, Inc. and Charles Russell. An Order, agreed upon by the parties, was entered by the Circuit Court in May 1985. The Order required Lenz Oil Service, Inc. and Charles Russell to initiate immediate clean-up actions and to file a closure and compliance plan. After failing to carry out major portions of the court order, Lenz Oil Service, Inc. ceased operations; and its owner, Charles Russell, filed for bankruptcy in April 1986.

3.3 History of Response Actions

In response to the November 19, 1980 application to develop and operate a waste management facility at the Lenz Oil Service, Inc. site, IEPA outlined several tasks that Lenz Oil Service, Inc. had to complete prior to the issuance of the requested operating permit. Several of these tasks were conducted by Soil Testing Services, Inc. (STS), on behalf of Lenz Oil Service, Inc. The tasks conducted by STS included the preparation of a contingency plan, leak testing of the three high-capacity underground storage tanks, installation of two monitoring wells (OW-1 and OW-2), collection of ground water samples from the monitoring wells, and preparation of a plan to limit further ground water degradation resulting from the operation of the Lenz Oil Service, Inc. facility.

Ground water samples were collected from monitoring wells OW-1 and OW-2 on April 8, 1981, October 23, 1981, and September 22, 1982. Oil and grease were detected in ground water samples collected from both monitoring wells during each round of sampling. The downgradient monitoring well (OW-2) exhibited the highest concentration of oil and grease each time. IEPA records indicate that both monitoring wells were sampled on a quarterly basis and that the samples were analyzed for a selected set of organic and inorganic constituents. Lenz Oil Service, Inc. made no additional attempt beyond installing and sampling OW-1 and OW-2, to

assess the extent of ground water contamination at their facility or to initiate a program to upgrade the ground water quality in the vicinity of the site, as required under the operating permit. However, in an attempt to prevent future degradation of the ground water quality by the Lenz Oil Service, Inc. operation, Lenz Oil paved the area where waste oils and solvents were transferred between tank trucks and underground storage tanks. This measure was approved by IEPA and was completed by Lenz Oil Service, Inc. during the first quarter of 1982.

In response to reports that Lenz Oil Service, Inc. was discharging waste material from surface impoundments at their facility to the drainage ditch north of their facility, IEPA notified Lenz Oil Service, Inc. on February 7, 1985, that these discharges were an apparent violation of Illinois statutes. Lenz Oil Service, Inc. informed IEPA that the company was in the process of pumping the liquid from the impoundments into on-site storage tanks where it would be held until proper disposal could be arranged. The material in the surface impoundment was reportedly crankcase oil with 10 to 20 percent water and was allegedly pumped into the impoundments as an emergency measure following the malfunction of oil lines at the facility. IEPA collected samples from the surface impoundment and the drainage ditch north of the facility. The analysis of these samples revealed elevated concentrations of organic compounds and metals in both samples. Pursuant to an anonymous complaint on April 24, 1985, IEPA inspected the Lenz Oil Service, Inc. site again and noted the presence of a milky white substance with a petroleum odor being discharged from the surface impoundments to the drainage ditch north of the site.

Later in April 1985, IEPA referred a law suit to the Illinois Attorney General's Office alleging illegal operation of surface impoundments by Lenz Oil Service, Inc. The parties quickly reached an agreement order; and on May 30, 1985, an immediate clean-up plan was filed by Hamman & Benn on behalf of Lenz Oil Service, Inc. Concurrent with the submittal of the immediate clean-up plan, Lenz Oil Service, Inc.: (1) pumped all contaminated liquids on the site into tanks for storage until approval for final disposal of the material was granted by IEPA, (2) recontoured

the surface of the site to halt the spreading of potentially hazardous liquid, and (3) blocked the flow of surface runoff to the drainage ditch north of the site. Arrangements were also made to sample the soil in the surface impoundments and the ground water in the on-site wells. Changes in operational procedures were also made to ensure that the use of the surface impoundments as an emergency containment area was no longer necessary. A further clean-up plan was filed by Hamman & Benn on behalf of Lenz Oil Service, Inc. on June 13, 1985.

In November 1985, the IEPA inspected the Lenz Oil Service, Inc. facility and observed that the facility was in general disarray and appeared abandoned. During their inspection, the IEPA was informed by Lenz Oil Service, Inc. personnel that the company was preparing to file for bankruptcy later in the month. According to the inspection report, 25 percent of the facility grounds were covered with standing oily water. Storage tanks were filled to the overflow point, and it did not appear that the facility had adequate spill or leak containment structures. After confirming the operating status of the facility and assessing the hazardous nature of the site, the IEPA prepared a Record of Decision (ROD) for the Remedial Action required at the Lenz Oil Service, Inc. site. The ROD was filed January 17, 1986 and amended January 15, 1987. The amended ROD stated that the Remedial Action activities at the Lenz Oil Service, Inc. site would be conducted in the following three phases: Phase I - Remedial Investigation, Phase II - Emergency Remedial Action, and Phase III - Site Remediation.

Phase I Remedial Investigation activities were conducted by IEPA and its contractors (Wehran Engineering Corp. and Petrochem Services, Inc.) between April 15, 1986 and November 30, 1986. The following tasks were completed during the Phase I Remedial Investigation:

- o On-site drums, tanks, and tank trucks were inventoried, sampled, and secured. Sample analyses indicated that the contents of the drums were predominantly oils, solvents, and tar waste and that the contents of the tanks and tank trucks were oils and solvents.

- o The site was surveyed with a magnetometer and a metal detector to identify buried objects such as piping systems and drums. A few small anomalies were identified, but the precise dimensions of the anomalies could not be determined and the buried objects were not identified.
- o Numerous surface and subsurface soil samples were collected and analyzed for organic compounds. Organic contaminants including solvents and petroleum-based products were detected in the soils at concentrations up to 2,000 ppm.
- o Eleven (11) monitoring wells, arranged in five-well clusters, were installed to evaluate the hydrogeology of the site and to assess the ground water quality at several intervals, ranging from 8 to 38 feet below ground level. Ground water samples contained various volatile organic compounds, semivolatile organic compounds, and some PCBs.
- o Potentially explosive storage tanks were blanketed with nitrogen, all tank penetrations were sealed, berms were constructed to reduce off-site drainage, and a local contractor was hired to conduct weekly inspections of the site to ensure that these emergency measures were maintained.

Based on the results of the Phase I investigation, the IEPA defined the scope of the Emergency Remedial Actions to be conducted under Phase II of the ROD. According to the ROD addendum, the scope of the proposed Emergency Remedial Action activities was not intended to result in complete restoration of the site. The activities were instituted to reduce the gross

immediate environmental hazards presented by the liquids, drummed waste, and leaking underground storage tanks at the site and, therefore, would result in remediation of approximately 100 percent of the on-site liquids, 100 percent of the drummed waste, and 60 percent of the contaminants in the soil.

During Phase II, a mobile rotary kiln incinerator operated by ENSCO was set up at the site to incinerate on-site liquids, drummed waste, and contaminated soil. According to Janssen (1988), the following tasks were conducted as part of the Phase II Emergency Remedial Action Program:

- o All drum, tank, and tank truck contents were incinerated.
- o The drums were shredded and incinerated, and the tanks and tank trucks were emptied, decontaminated, and transported off site.
- o All aboveground and underground structures were removed.
- o Soil in the vicinity of the underground storage tank farms and buried drums was excavated to a depth of 9 to 11 feet (i.e., the top of bedrock) and incinerated (see main excavation area, Figure 3-3).
- o Hot spots in the area of the former surface impoundments were excavated and incinerated.
- o In April 1988, municipal water was made available to residences on Jeans Road and all residences formally using private wells in the immediate vicinity of the site.

A total of 21,000 tons of contaminated soil was excavated and incinerated, and the ash was returned to the excavation area (Figure 3-3). The quantities of soil removed from the main excavation area and from hot spots outside the main excavation area are unknown. Excavation of contaminated soil was reportedly carried out until bedrock was encountered in the vertical direction and until the native soil lateral to the excavation area was found to contain less than 5 ppm total volatile organic compounds. This was achieved in most places at a depth of 9 to 11 feet below ground surface, which corresponds with the top of bedrock. During remediation of soil in the main excavation area, the IEPA had a 10-mil (0.0001-inch) layer of pond-liner-grade visqueen installed above the bedrock, at the base of the excavation pit. Visqueen was installed manually, and overlapping layers of the visqueen were solvent welded. The liner covers the entire main excavation area, including the floor, sidewalls, and approximately one (1) foot of the level ground surrounding the excavated area. Incinerator ash was then placed above the visqueen as backfill material. The hot spot excavation areas were not lined with visqueen, but were backfilled with clean material rather than incinerator ash. Information concerning the soil excavation, liner installation and incineration activities was gathered from Janssen (1988), Janssen (1990), IEPA (1990) and Gardenour (1990).

According to the amended ROD, IEPA had intended to construct a slurry wall dividing and segregating the highly contaminated portion of the Lenz Oil Service, Inc. facility (the southwest one-half of the operating site) from the less contaminated (northeast) portion of the site. There is no indication in the Phase II records that this slurry wall was constructed. The amended ROD also calls for the design and installation of a permanent cap over the portion of the Lenz Oil Service, Inc. site that met clean-up objectives. Other than covering the site with top soil and planting grass, there is no indication that a permanent cap was constructed at the site (Figure 3-3). Phase II activities were completed in July 1988.

Amended
ROD
Non
Compliant

Phase III of the amended IEPA ROD was to be conducted simultaneously with Phase II and was to include placing the Lenz Oil Service, Inc. site on the CERCLIS list and conducting the required screening activities to score the site for the National Priorities List (NPL). Assuming the site scored high enough to be placed on the NPL, an RI/FS would be conducted at the site, an appropriate remedy would be designed and constructed, and the IEPA would petition the USEPA for the State's cost-share reimbursement of non-federal expenditures.

On October 23, 1984, the IEPA identified the Lenz Oil Service, Inc. site as a potential hazardous waste site to the USEPA in the form of a Preliminary Assessment (USEPA, 1984). A site inspection was conducted by Wehran Engineering, and a potential hazardous waste site inspection report was submitted on August 14, 1987. On October 2, 1987, a Hazard Ranking Score (HRS) report for the Lenz Oil Service, Inc. site was filed with USEPA Region V. The USEPA proposed that the Lenz Oil site be included on the National Priorities List (NPL) in June 1988 with a HRS score of 42.33 (USEPA, 1987). The score was based on conditions at the facility that existed prior to the IEPA's Emergency Remedial Activities. The NPL listing became final in September 1989. On November 28, 1989, the USEPA and the Lenz Oil Service, Inc. Participating Respondents signed an Administrative Order by Consent to perform an RI/FS of the Lenz Oil Service, Inc. site. In accordance with the Consent Order, ERM-North Central, on behalf of the Lenz Oil Service, Inc. Participating Respondents, submitted an RI/FS Work Plan for the Lenz Oil Service, Inc. site to the USEPA on January 22, 1990. The Work Plan was approved by USEPA Region V and the IEPA on December 18, 1990.

On March 30, 1988, the Lenz Oil Service, Inc. Participating Respondents entered into a judicial Consent Decree with the IEPA and the State of Illinois that constitutes a full settlement of certain current and future site clean-up costs (DuPage County Circuit Court, 1988). The Consent Decree provides that in the event the USEPA requires additional remedial activities at the site, other than ground water remediation, such additional remediation "shall be dealt with by the State."

3.4 Historical Aerial Photograph Analysis

ERM conducted an analysis of historical and current aerial photographs of the Lenz Oil site to better assess the history of operations at the site. All of the aerial photographs of the site available from the U.S. Department of Agriculture were reviewed. These photographs document the physical conditions and the expansion of operations at the Lenz Oil site. Seven black and white photographs representing a period of 34 years (1954-1988) were used as part of this analysis. Photographs from 1954, 1961, 1967, 1971, 1974, 1981, and 1988 were reviewed and interpreted. Table 3-5 provides summary information on the aerial photographs used for analysis.

Topics addressed in the photo analysis include: (1) operations expansion, (2) storage areas, (3) waste disposal areas, and (4) drainage patterns. The results of the analysis are shown on seven annotated figures (Figures 3-4 to 3-10), each representing a interpretation of an aerial photograph.

3.4.1 1954 Aerial Photograph

The 1954 photograph (Figure 3-4) shows the condition of the site prior to the establishment of the Lenz Oil facility. The site was mainly an open field with portions of the east side of the site covered with woods. The vegetation on the east half of the site was a darker shade than the vegetation on the west half of the site. The reason for the variation in vegetation color is unknown.

Two buildings existed at the east corner of the site. The westernmost building may be a residence or former residence; the other is a garage or large shed. A drainage ditch and railroad

tracks were adjacent to the northwest boundary of the site. A farm was located to the south, across Jeans Road from the site. The site was bound by State Route 83 to the west and a wooded area (future Corwin Lenz residence) to the east.

3.4.2 1961 Aerial Photograph

Based on changes in site features shown on the 1954 and 1961 photographs, it is clear that Lenz Oil Services, Inc. began operating between 1954 and 1961. By 1961 (Figure 3-5), a maintenance building had been constructed at the south-central portion of the site, and the underground tank farm immediately north of the maintenance building was in place. Aboveground tanks, tankers, and possibly drums were located in an area west of the underground tank farm. Immediately west of this location was a cleared area or a cement pad. At least three tank trucks were parked on the site. The house noted on the 1954 photograph may have been converted to an office building by the time the 1961 photograph was taken.

3.4.3 1967 Aerial Photograph

Between 1961 and 1967 (Figure 3-6), another underground tank farm was constructed north of the underground tank farm noted in the 1961 photograph, and a cluster of aboveground tanks was established west of the underground tank farm. An area of disturbed soil and/or unidentified objects was located to the east of the southern underground tank farm. A parking shed, located in the western portion of the site, was also constructed between 1961 and 1967. The south half of the parking shed was covered with a roof in 1967, but the north half of the shed was not yet covered. A trailer or mobile home was situated just east of the property, and an area of scattered unknown objects was located immediately northeast of the mobile home. Several tank trucks were parked on the site.

3.4.4 1971 Aerial Photograph

Three aboveground tanks were installed around the maintenance building between 1967 and 1971 (Figure 3-7). A metal shed was constructed between the three underground tank farms north of the maintenance building. Another underground tank farm was built immediately west of the aboveground tank farm located on the western portion of the site. The north half of the parking shed was covered by 1971. A surface impoundment, containing liquid, was present for the first time in the 1971 photograph. Two large areas of disturbed ground and/or unidentified objects surrounded the impoundment. Several tank trucks were parked around the site, which may have been partially enclosed with a fence.

3.4.5 1974 Aerial Photograph

Two large cylindrical aboveground tanks were added near the center of the property between 1971 and 1974 (Figure 3-8). A large rectangular aboveground tank was installed north of the cylindrical tanks. Another tank farm was constructed north of this large rectangular aboveground tank. The surface impoundment was still present in 1974 and still contained liquid. Several tank trucks were parked around the site. A mobile home or tank truck was located just east of the site, on the Corwin Lenz property.

3.4.6 1981 Aerial Photograph

Additional aboveground tanks were added to the tank farm north of the cylindrical tanks (Figure 3-9). A small underground tank farm was added east and adjacent to the aboveground tank farm, located east of the parking shed. The surface impoundment noted in previous photographs may have been present in 1981, but it is not clear from the photograph. Because of the apparent absence of water in the area (as shown on the 1981 photograph), this feature may be the

previously identified surface impoundment or a cinder pile. Several tank trucks were parked around the site.

3.4.7 1988 Aerial Photograph

It is clear from the 1988 photograph (Figure 3-10) that operations had ceased at the Lenz Oil Service, Inc. facility by that time and that remedial activities had begun. An incinerator and a support area were established on the east side of the site. Approximately 75 percent of the site appeared to have been excavated to various degrees. However, the site's main structures (i.e., the maintenance building, parking shed, and office building) were still present.

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Preliminary Conceptual Site Model

A preliminary conceptual site model has been developed for the Lenz Oil site that represents the contaminants present, their routes of migration, and potential receptors (Figure 4-1). The purpose of the conceptual model is to aid in the selection of sampling locations and to help identify and evaluate potential remedial alternatives. Information obtained during the RI activities will be used to fine tune the model.

The model was developed by considering and evaluating: (1) the documented history of activities conducted at the Lenz Oil site, and (2) the data collected during the remedial activities undertaken by IEPA and its contractors (see Section 3.3). Because some remedial activities have already been conducted at the site, this model attempts to reflect both pre- and post-remediation conditions at the site. The following subsections describe each aspect of the conceptual model in further detail.

4.2 Primary Contamination Sources

Four primary sources of contamination were identified at the Lenz Oil site: drums, tanks, tank trucks, and surface impoundments. According to IEPA records, a total of 197 drums, 27 tanks, 8 tank trucks, and 3 surface impoundments were located at the site. Although the contents of some of these sources were sampled and analyzed prior to 1986, a coordinated sampling effort was not conducted until the summer and fall of 1986. The permanent locations of the tank farms and drum storage areas are shown on Figures 3-1 and 3-2. An approximate location of the surface impoundment area is also indicated on these figures; however, the impoundments were

allegedly moved several times during the operation of the Lenz Oil facility and were not present during the time the IEPA conducted remedial activities.

ERM-North Central divided the laboratory analytical results for the primary sources into groups representing drums, tanks, tank trucks, and surface impoundments. The analytical results show that the drums, tanks, and tank trucks contained similar types and concentrations of contamination. Because of their similar contaminant characteristics and their proximity to each other, the drums, tanks and tank trucks are considered a single homogenous primary source. As shown in Table 4-1, the drums, tanks, and tank trucks contained elevated concentrations of metals, cyanide, semivolatile organic compounds, volatile organic compounds, and, to a lesser degree, PCB contamination.

The surface impoundment located in the northeastern section of the site was inspected by the IEPA on April 24, 1986 and according to the IEPA inspection report, the contents of the impoundment consisted of a milky white substance with a petroleum odor. ERM-North Central reviewed the limited analytical data describing the contents of this impoundment area; these data indicate elevated concentrations of organics and metals (Table 4-2). Although the contaminant characteristics are similar to those of the drums, tanks, and tank trucks, the surface impoundment will be considered a separate primary source because of its separate location and potential differences in primary release mechanisms.

Because the foregoing primary sources were incinerated by the IEPA in 1986, they have not contributed to further contamination at the site. However, due to poor operating procedures and inadequate housekeeping practices by Lenz Oil Service, Inc., contaminants were released to the on-site soil prior to the IEPA remedial activities. Because the analytical results discussed in this section represent only a small portion of the waste handled by Lenz Oil Service, Inc., these data may not fully describe the types and concentration ranges of contaminants released to the environment.

4.3 Primary Release Mechanisms

The primary release mechanisms of contaminants at the Lenz Oil site include surface water runoff, infiltration, volatile emissions, and transport by dust and other particulate matter (see Figure 4-1). An IEPA site inspection conducted in November 1985 indicated that 25 percent of the facility grounds were covered with standing oily water. Storage tanks were reported to be at the overflow points and did not appear to have adequate spill or leak protection. Also, as noted previously, the contents of the surface impoundment were directly discharged into the drainage ditch on the north side of the facility.

Based on IEPA's records and the characteristics of contaminants in the primary sources, all of the aforementioned primary release mechanisms contributed to the release of contamination. Perhaps the most significant release mechanisms were spillage and leakage from drums, tanks, and tank trucks resulting in subsequent contaminated surface water runoff and infiltration into the area soils.

4.4 Secondary Contamination Sources

Surface and subsurface soils on the Lenz Oil site were sampled and analyzed by the IEPA and its contractors in 1986 (Wehran Engineering, 1987). Although the majority of the soil samples were taken from the northeastern side of the site, samples were collected from various locations and depths across the entire site (Figure 3-2). Insufficient data exist to characterize soil contamination around some of the primary sources, and the analytical results that do exist generally show similar contaminant types and concentration ranges regardless of proximity to individual primary sources areas. Furthermore, the soil samples contained many of the same contaminants detected in the primary sources, but at lower concentrations (Table 4-3). Only a few soil samples contained higher concentrations of contaminants than the primary sources.

As indicated in Section 3.3, approximately 21,000 tons of on-site contaminated soils were excavated and incinerated. The relative quantities of soil removed from the main excavation and areas considered as hot spots are, however, not known. Incinerated ash was used as backfill material in the main excavation areas and, thus, represents another potential secondary source of contamination. Samples of incinerated ash were collected by the IEPA and/or its contractor to evaluate the effectiveness of the incinerator in reducing soil contamination and to document the quality of the ash used to backfill the excavation area. Based on available analytical data, it appears that samples of the ash were analyzed for semivolatile organic compounds and occasionally volatile organic compounds. There is no record of metal analyses for the ash. As indicated in Table 4-4, only a few samples of the ash contained semivolatile or volatile organic contaminants at concentrations above the detection limits. It is unclear whether or not the contaminated ash was further incinerated or if it was used as backfill. Analytical data from "tent samples" show considerable organic contamination (Table 4-5), but the origin and final destination of the "tent sample" material is unknown.

The analytical results for the incinerated ash are a measure of the post-remediation site conditions in the main excavation area. Unfortunately, because the ash was analyzed for an incomplete set of analytical parameters, the actual quality of the backfilled ash is unknown. While the analytical results for the surface and subsurface soils are a measure of the pre-remedial site conditions, only soils exhibiting a total volatile organic concentration greater than 5 ppm were excavated and incinerated. Thus, some contaminated soil remained at the site after remediation. The IEPA is currently collecting soil samples from the incinerated ash backfill, the native soil around the main excavation area, and the soil around the former surface impoundment area. Analytical results from these soil samples will be used to re-evaluate the contaminant characteristics of the secondary sources.

4.5 Secondary Release Mechanisms

The release mechanisms for the secondary sources are similar to those identified for the primary sources. The significant mechanisms in this case are infiltration/percolation, surface water runoff, and dust and other particulate emissions. Infiltration/percolation releases contaminants in the secondary sources (i.e., on-site soil and/or incinerated ash) directly to the ground water migration pathway. Surface water runoff releases contaminants found in the surface soil and incinerated ash directly to the surface water migration pathway and indirectly (i.e., through infiltration/percolation as well) to the ground water migration pathway. Surface soil contaminants may also be released to the air migration route via dust or other particulate emissions.

Surface water runoff from the site appears to drain in a westerly direction along a well-defined ditch on the north side of the facility. The drainage ditch directs flow towards the Des Plaines River. Judging from the proximity of the river, the length of overland flow is estimated as 1,000 to 1,500 feet. Because of the generally flat terrain on and around the site, ponding during rainfall events may occur, resulting in a natural attenuation of contaminants reaching the Des Plaines River. Conversely, areas in which ponding occurs may act as short-term detention ponds for conservative contaminants. During rainfall events, these areas may result in a "first flush" of contamination in the runoff ultimately discharging into the Des Plaines River.

4.6 Migration Pathways

The ground water and surface water pathways are the most likely routes of migration for contamination at the Lenz Oil site. Significant airborne contaminant migration is not considered likely since all of the primary contaminant sources have been eliminated, which leaves dust and other particulates generated from secondary contaminant sources as the only potential airborne

material. Any direct contact and fire/explosion risks were probably eliminated by the IEPA remediation of on-site soils. However, because not all of the on-site soils were remediated and the composition of the backfill is unknown, secondary sources of contamination may still release contamination to the air and pose a minor risk of direct contact.

The local ground water system is the primary migration pathway from the Lenz Oil site. Samples collected from local monitoring wells and residential wells have documented the presence of volatile organics, semivolatile organic, metals, and PCBs in the ground water system. The PCBs were only detected in on-site monitoring wells near the source area. Table 4-6 shows the private wells sampled by IEPA, their locations, sampling dates, and the parameters analyzed. The types of contaminants and ranges of concentrations detected in ground water samples from private and monitoring wells are indicated in Tables 4-7 and 4-8, respectively.

The highest concentration of ground water contamination is centered around the G-105 monitoring well cluster, which is located between the former northern tank farm and drum storage area (Figure 4-2). Lesser amounts of contamination were detected to the south and southeast, in well clusters G-102, G-104, and G-106. Several common laboratory contaminants, were detected in the upgradient well cluster, G-101. Because all but one of these contaminants were detected in the laboratory method blank, the upgradient samples are considered free of site-related contamination.

The distribution of contaminants in ground water suggests the presence of a southeastward migrating plume containing a variety of volatile organics, semivolatile organics, and metals. The wells furthest from the site containing ground water contamination are G-102L, G102D, and the Williams Bait Shop Residential Well. Low concentrations of several volatile organic compounds and one semivolatile organic compound have been detected in all of these wells.

Based on the IEPA ground water data from July 29, 1986 and June 30, 1987, the plume is present at 30.8 feet below the ground surface and extends at least 60 feet downgradient of the site.

Surface water and sediment in the drainage ditch adjacent to the Lenz Oil site are also potential pathways of contaminant migration from the site. The drainage ditch flows into the Des Plaines River southwest of the site. Based on our review of available site data, the potential effects of contamination from the Lenz Oil site on the water and sediment in the drainage ditch have not been previously evaluated.

4.7 Potential Receptors

One of the objectives of the Lenz Oil Service, Inc. RI, as stated in the Work Plan, is to identify potential receptors of contamination migrating from the site. In an initial evaluation of potential receptors, conducted prior to the preparation of the Work Plan, the following groups of potential receptors were identified: ground water and surface water users, wetlands, and endangered/threatened species. Subsequently, fish in the Des Plaines River have been added to this list of potential receptors. These groups of potential receptors have been evaluated in greater detail as part of Phase I, Task 1, and the results of that evaluation are discussed in the following subsections. This information will be used to reevaluate the preliminary conceptual site model and help direct sampling efforts toward the migration pathways most likely to affect the identified potential receptors. Receptor data will also become part of the Lenz Oil site Risk Assessment.

4.7.1. Ground Water Users

According to the HRS package for the Lenz Oil site (USEPA, 1987), ground water users are the primary receptors of concern. The USEPA estimates that 11,335 people use drinking water obtained from wells located within three miles of the Lenz Oil site (USEPA, 1987). All of the wells allegedly draw water from the Silurian dolomite aquifer, and supposedly no alternative water supplies (i.e., municipal water obtained outside the three-mile radius) exist in the area (USEPA, 1987). Because the HRS model, by which these estimates were derived, does not take into account ground water flow direction, ground water divides/discharge areas, or remedial activities, the USEPA estimate is not an accurate indication of the number of ground water users potentially receiving contamination from the site.

Accordingly, ERM-North Central has conducted a ground water usage survey for the area within two miles of the Lenz Oil site. The survey included a review of all of the water well records available from the Illinois Geological Survey and the Illinois State Water Survey for the area of interest as well as water usage records for local water systems. These ground water usage data were then analyzed in terms of the actual hydrogeologic system operating at the Lenz Oil site. The purpose of the water usage survey was to determine: (1) the usable aquifers in the area; (2) the number, type, and location of wells in the vicinity of the site; (3) the construction (i.e., depth, casing, screen materials, and screened intervals) of the wells in the area; (4) the number and location of wells that pump water from the potentially contaminated aquifer; and (5) the wells that are suitable candidates for sampling during Phase II of the RI.

A total of 310 residential, commercial, and industrial wells were identified from the well construction records as being located within approximately two miles of the Lenz Oil site. To facilitate an evaluation of these wells, each well was placed into one of the following three categories: (1) individual wells within one mile of the site, (2) individual wells between one and

two miles of the site, and (3) groups of wells within two miles of the site. The third category was necessary because high well density in some areas made it impractical to accurately locate individual wells. Exact locations of individual wells within each group will be determined, if necessary.

As shown on Figure 4-3, well records indicate, 22 individual wells are located within a one-mile radius of the site and 73 individual wells are situated between one and two miles of the site. Eight groups containing a total of 198 wells are located within two miles of the site; most of these wells (approximately 160) are located between one and two miles from the site. Seventeen wells, located just outside the two-mile radius, were also included in the survey. Table 4-9 lists the following information for each well identified within a two-mile radius of the site: location, installation owner, date, total depth, screen material, screened interval, static water level, and geologic material opposite the screened interval. Each well was also given a unique number, which is listed on Table 4-9 and shown with the corresponding well location on Figure 4-3.

A careful review of the water well logs has shown that only seven wells are completed in the glacial drift aquifer and that all of the remaining 303 wells are completed in the Silurian dolomite aquifer (Table 4-9). Some of the wells completed in the Silurian dolomite aquifer extend a few feet into the underlying Maquoketa shale, but none of the wells penetrate the Maquoketa shale and draw water from the underlying Cambrian-Ordovician aquifer. As discussed in Section 2.8, most wells that utilize the Silurian dolomite aquifer are completed within the upper 65 feet of the aquifer. In general, a steel casing is used to seal off the overlying glacial drift or alluvial deposits, and the rest of the borehole is left open.

Although the static water levels reported on water well records are of limited use for a detailed analysis of ground water flow, they can be used to identify regional ground water flow trends. The static water level data included on Table 4-9, support the interpretation that ground water

in the Silurian dolomite aquifer flows from upland areas, where the aquifer is recharged, toward the Des Plaines River Valley and the Calumet Sag Channel Valley, where the aquifer discharges. Because ground water flows toward the southeast on the north side of the Des Plaines River Valley, all of the private wells located northwest of the Lenz Oil site are upgradient of the site, and should not be considered potential ground water receptors. Additionally, the wells located southeast of the Des Plaines River Valley are hydraulically isolated from ground water passing under the Lenz Oil site by the Des Plaines River discharge area and, therefore, should not be considered potential ground water receptors.

The area potentially impacted by ground water contamination from the Lenz Oil site is, thus, confined to the south one-half of Section 11, T37N, R11E. This area includes all of the wells between the Lenz Oil site and the Des Plaines River, and a few wells lateral to the site. The following private wells have been identified as potential candidates for sampling during Phase II of the RI, pending the results of Phase I Task 2:

- o ERM Well No. 235
 Owner: Dupage County Forest Preserve, Well No. 83-2
 Location: T37N, R11E, Sec. 11, NW 1/4 of NW 1/4 of SW 1/4
 Well depth: 200 feet.

- o ERM Well No. 233
 Owner: Corwin Lenz
 Location: T37N, R11E, Sec. 11, SE 1/4 of NW 1/4 of SE 1/4
 Well Depth: 125 Feet

- o ERM Well No. 232
 Owner: Thomas Redichs

Location: T37N, R11E, Sec. 11, NE 1/4 of NW 1/4 of SE 1/4
Well Depth: 100 Feet

- o ERM Well No. 217
Owner: Richard Flacs
Location: T37N, R11E, Sec. 11, SE 1/4
375 Jeans Road
Well Depth: 100 Feet
- o ERM Well No. 234
Owner: Nick Batistich
Location: T37N, R11E, Sec. 11, SE 1/4 of NE 1/4 of SW 1/4
16W 115 99th Street
Well Depth: 165 Feet

The previous list represents all of the wells in the south half of Section 11 for which water well records exist. The IEPA previously collected ground water samples from the well owned by Corwin Lenz (ERM Well No. 233) and from several other wells in the vicinity of the site. Because water well records are not available for the other wells that IEPA sampled, pertinent information regarding the location and construction of these wells is limited or missing. Nonetheless, each of these wells is considered a potential candidate for sampling and will be investigated further. The following is a list of the private wells sampled by IEPA for which water well records do not exist:

- o Well Owner: Schuster
Location: 11 S. 305 Jackson Street

- o **Well Owner: Gruber**
 Location: Jeans Road
- o **Well Owner: Williams Bait Shop**
 Location: Jeans Road
- o **Well Owner: Kempa**
 Location: 16W 414 99th Street
- o **Well Owner: Flacks**
 Location: 97th Street
- o **Well Owner: Mason**
 Location: Jeans Road
- o **Well Owner: Stein Haus**
 Location: None Given
- o **Well Owner: Knollwood**
 Location: None Given

Because municipal water service was provided to all residences in the vicinity of Lenz Oil site as part of the IEPA remedial activities conducted in 1988, it is likely that many, if not all, of the previously mentioned candidates for private well sampling are no longer in use. Thus, all of the potential candidate wells will be further investigated prior to proposing the final private well sampling locations in the Work Plan for Phase II activities.

4.7.2 Surface Water Users

As discussed in Section 2.6, runoff from the Lenz Oil site enters the drainage ditch northwest of the site and eventually infiltrates the soil or discharges to the Des Plaines River southwest of the site. ERM-North Central conducted an assessment of water usage for a two-mile stretch of the Des Plaines River, downstream of the Lenz Oil site. Inquiries were made to the Metropolitan Water Reclamation District and the Illinois State Water Survey regarding the types and locations of potential water users along the Des Plaines River, downstream of the site. Neither Agency was aware of any water users in the target area that withdrew water from the Des Plaines River, the Chicago Sanitary and Ship Canal, or the Illinois and Michigan Canal for drinking water purposes. However, several industries in the area obtained their process water from the Chicago Sanitary and Ship Canal. Prominent industrial users include the Union Oil Refinery at Romeoville and the Commonwealth Edison Power Plant, located directly across the Des Plaines River Valley from the Lenz Oil site. No other surface water users that have been identified.

4.7.3 Wetlands

Wetlands have been identified in the vicinity of the Lenz Oil site from an interpretation of aerial photographs and topographic maps of the area. Wetlands were defined as low-lying marshy areas and were not classified according to biota. As shown on Figure 2-3, several wetlands are present within a one-mile radius of the site. All of the wetlands are located within the Des Plaines River Valley, and all appear to be perched above isolated layers of impermeable soil material. Field inspections of the wetlands closest to the site revealed that they have been reduced in size by filling activity. For example, the area mapped as a wetland to the northeast of the Lenz Oil site and south of the Atchison, Topeka, and Santa Fe Railroad appears to be completely covered with fill, with the exception of a low area on the northern portion of Corwin

Lenz's property (Figure 2-1). The relatively large marshy area southeast of the site, across Jeans Road, appears to be partially occupied by an auto scrap yard (Figure 2-3). The extent to which this wetland has been altered by the activities of the scrap yard has not been established. Extensive, undisturbed wetlands exist at two locations on the strip of land between the Des Plaines River and the Chicago Sanitary and Ship Canal, one approximately 1,000 feet southeast of the site and the other approximately 5,000 feet southwest of the site (Figure 2-1). An extremely large wetland area is located along the Calumet Sag Channel, approximately two miles southeast of the site (Figure 2-1).

4.7.4 Endangered or Threatened Species

The Illinois Department of Conservation's Natural Heritage Database was accessed to determine the presence of Federal- and State-listed endangered/threatened species in the immediate vicinity of the Lenz Oil site. The database shows no record of Federal- or State-listed threatened/endangered species within a one-mile radius of the site; however, the following State-listed threatened/endangered species have been sighted within a five-mile radius of the site.

<u>Common Name</u>	<u>Status</u>
Pied-billed grebe	Endangered
Red-shouldered hawk	Endangered
Veery	Threatened
River otter	Endangered
Blazing star	Threatened
Hairy marsh yellow cress	Endangered
Awned sedge	Endangered
Crawe sedge	Threatened

In addition to the State-listed species presented above, three nature preserves and five high-quality nature areas are legally protected by the State of Illinois. These protected areas include:

<u>Name</u>	<u>Location</u>
Cap Sauers Holding Nature Preserve	T37N, R12E, Sec. 18
Paw Paw Nature Preserve	T37N, R12E, Sec. 5
Sagawau Canyon Nature Preserve	T37N, R11E, Sec. 13
Waterfall Glen Nature Area	T37N, R11E, Sec. 9
Cap Sauers Holding Nature Area	T37N, R12E, Sec. 12
Lemont East Geological Area	T37N, R11E, Sec. 15
Paw Paw Woods Nature Area	T37N, R12E, Sec. 5
Sagawau Canyon Nature Area	T37N, R11E, Sec. 13

This information is a summary of the existing data available to the Division of Natural Heritage.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The overall objective of the activities conducted during Phase I, Task 1 of the Lenz Oil Service, Inc. RI, and described herein, was to refine the investigative effort for Phase I, Task 2 and Phase II, Task 1. Specifically, data generated during Phase I, Task 1 were intended to fine tune the preliminary conceptual site model and assist in identifying additional sampling locations, or modifying the existing sampling plan. As a result of Phase I, Task 1 activities, the following changes were made to the preliminary conceptual site model presented in the Lenz Oil Service, Inc. Work Plan:

- o The surface impoundment area was added to the list of primary contamination sources,
- o Spillage and leakage were added to the list of primary release mechanisms, and
- o Incinerator ash was added to the list of secondary contamination sources.

Although the preliminary conceptual site model has been revised, the scope of sampling described in the Work Plan for RI Phase I, Task 2 was designed in anticipation of these changes to the model. Specifically, the source characterization activities were designed to include sampling the incinerator ash and the soil in the area of the former surface impoundments to evaluate the nature and extent of contamination in these two secondary sources. The addition of spillage and leakage to the list of primary release mechanisms also has no affect on the proposed sampling plan. Therefore, no additional sampling locations or modifications to the existing Phase I, Task 2 activities are proposed as a result of the revised conceptual site model.

A secondary objective of the Phase I, Task 1 activities was to re-evaluate the locations and depths of proposed monitoring wells after reassessing the ground water flow direction at the site and conducting a regional fracture analysis. As discussed in Section 2.8 of this document, water level data collected by ERM-North Central in January, 1991 confirmed that shallow ground water below the Lenz Oil site flows toward the Des Plaines River. This is consistent with the ground water flow direction presented in the Work Plan, which was used as the basis for selecting the original monitoring well locations.

The results of the regional fracture analysis, as described in Sections 2.7 and 2.8 of this document, pointed out the presence of: (1) laterally extensive, solution-enlarged, horizontal joints, and (2) two orthogonal sets of vertical joints, in the Silurian dolomite aquifer below the site. According to Nicholas and Healy (1988), the primary conduits for ground water flow in the dolomite aquifer are: (1) a rubbly and highly permeable weathered zone at the top of the dolomite, and (2) the uppermost set of solution-enlarged horizontal joints in the dolomite. The shallow horizontal joints are located at elevations of 550 and 565 feet above sea level, which correspond to approximate depths of 35 and 50 feet below ground surface at the Lenz Oil site. The Work Plan requires that monitoring well borings be drilled at least 30 feet below the water table, which corresponds to an approximate total depth of 40 feet below the ground surface. Thus, the monitoring well installation program proposed in the Work Plan and Sampling and Analysis Plan is sufficient to allow placement of: (1) shallow monitoring well screens opposite the weathered zone at the top of the dolomite aquifer, and (2) deep monitoring well screens opposite of the uppermost horizontal joint set. The program is also flexible enough to permit placement of the deep well screen at a deeper more transmissive interval, if the upper joint set is shown to be a poor conduit for ground water migration. Therefore, both of the primary conduits for ground water flow in the Silurian dolomite aquifer can be monitored without changing the monitoring well installation procedure outlined in the Work Plan.

Although Nicholas and Healy (1988) identified two orthogonal sets of vertical joints in the Silurian dolomite aquifer, the location of individual vertical joints is not a predictable feature, but one that has to be confirmed by observation. Because no lineaments transecting the site were observed in the aerial photograph analysis and no outcrops are present on the site or between the site and Des Plaines River, there is presently no useful vertical joint data available to guide the placement of the monitoring well clusters. However, Nicholas and Healy (1988) suggest that ground water, and presumably contaminant, migration occurs primarily through solution-enlarged horizontal joints; therefore, the inability to place monitoring wells at vertical joint locations is probably of lesser significance to the ground water investigation. In conclusion, no changes to the monitoring well locations, depths, or installation procedures are recommended as a result of the re-evaluation of the ground water flow direction and analysis of regional bedrock fracture trends. However, revised monitoring well locations are being proposed as a result of the soil gas investigation. The soil gas investigation results and the proposed monitoring well location changes are presented in Technical Memorandum No. 2.

A third objective of the Phase I, Task 1 activities was to identify potential candidate wells for private well sampling during Phase II, Task 1 activities. As discussed in Section 4.7.1 of this document, 13 private wells have been identified as potential candidates for sampling during Phase II of the RI. Nine of the wells have been previously sampled by IEPA, but only one of the sampled wells has sufficient information regarding the location and construction of the well. Four other wells were identified through a review of water well records available from the Illinois Geological Survey and the Illinois State Water Survey. Because information regarding the location and construction of many of these candidate private wells is limited or missing, further evaluation of all the wells is necessary prior to proposing the final private well sampling locations. Furthermore, municipal water service was provided to all of the residences in the vicinity of the Lenz Oil site as part of the IEPA remedial activities conducted in 1988; therefore, it is likely that many, if not all, of the candidate wells are no longer in use. All of the candidate

Lenz Oil Site RI/FS
Technical Memorandum No. 1
Revision: 1
May 2, 1991
Page: 5-4

wells identified in Section 4.7.1 for sampling during Phase II of the RI will be carefully screened prior to proposing final private well sampling locations in the Work Plan for Phase II activities.

REFERENCES

DuPage County Circuit Court, 1988, State of Illinois vs. Lenz Oil Service, Inc., et al., Partial Consent Decree Between Plaintiffs and Certain Defendants, dated March 30, 1988.

ERM-North Central, Inc., 1990, Remedial Investigation/Feasibility Study Work Plan, Lenz Oil Service, Inc., Lemont, Illinois, Revision 3; November 12, 1990.

Foote, G.R., 1982, Fracture Analysis in Northeastern Illinois and Northern Indiana; M.S. Thesis, University of Illinois, 193 p.

Gradenour, K.E., 1990, Signed statement describing responsibilities and observations during previous Lenz Oil remedial activities.

Gibb, J.P., 1965, Report on Ground Water Conditions in Section 3, T37N, R11E, DuPage County, Illinois, Illinois State Geological Survey, 2 p.

IEPA, 1981, letter to Lenz Oil Service, Inc., written by Thomas E. Cavanagh, Jr., Manager Residual Management Section, Division of Land/Noise Pollution Control, RE: Development Permit No 1981-36-DE, dated July 5, 1981.

IEPA, 1985, Memorandum to Jim Janssen and Jim Frank, written by Steve Colantino, RE: Lenz Oil Service, Inc., dated November 18, 1985.

IEPA, 1990, Sampling Plan for the Lenz Oil Site, prepared by EBASCO Services, Inc., dated January 5, 1990.

Janssen, J., 1988, telephone conversation, IEPA project manager for Lenz Oil site remediation, conducted by David P. Edwards, ERM-North Central, Inc., RE: Lenz Oil Site Remediation.

Janssen, J., 1990, Memorandum to David Dollins, written by James Janssen, IEPA, RE: Lenz Oil Site, Liner Installation, dated July 26, 1990.

Kraatz, P., 1964, Geologic Report on the Ground-Water Conditions for a Domestic Supply in Section 2, T37N, R11W, DuPage County, Illinois; Illinois State Geological Survey, 2 p.

Nicholas, J.R. and Healy, R.W., 1988, Tritium Migration from a Low-Level Radioactive-Waste Disposal Site near Chicago, Illinois; U.S. Geological Survey Water-Supply Paper 2333. 46 p.

Nicholas, J.R. and Shapiro, A.M., 1986, Hydraulic Characteristics of a Jointed Dolomite Beneath a Low-Level Radioactive-Waste Disposal Site; American Geophysical Union Transaction, V. 67, No. 160.

Olimpio, J.C., 1984, Low-Level Radioactive-Waste Burial at the Palos Forest Preserve, Illinois: Geology and Hydrology of the Glacial Drift, as Related to the Migration of Tritium; U.S. Geological Survey Water-Supply Paper 2226, 34 p.

Papadopoulos, I.S., 1965, Nonsteady Flow to a Well in an Infinite Anisotropic Aquifer: International Association of Scientific Hydrology, Dubrovnik Symposium on Hydrology of Fractured Rock, Proceedings, v. 1, p 21-31.

Sherman, F.B., 1968, Geologic Report on the Ground-Water Conditions for a Municipal Supply in Section 3, T37N, R11E, DuPage County, Illinois; Illinois State Geological Survey, 2 p.

Smith, H.F., 1946, Report on Ground Water Resources in Section 5, T37N, R11E, DuPage County; Illinois State Geological Survey, 1 p.

Storm, R.R., 1946, Geological Report on the Ground Water Possibilities in Section 5, T37N, R11E, DuPage County; Illinois State Geological Survey, 1 p.

USEPA, 1984, Potential Hazardous Waste Site Preliminary Assessment for Lenz Oil Service, Inc., dated October 23, 1984.

USEPA, 1987, Hazard Ranking System Score and Documentation for Lenz Oil Service, Inc., dated October 2, 1987.

USEPA, 1989, Administrative Order by Conent, RE: Remedial Investigation and Feasibility Study, in the Matter of Lenz Oil Service, Inc., et al., November 23, 1989.

Walker, W.H., 1964, Report on Ground-Water Availability in Section 2, T37N, R11E, DuPage County, Illinois; Illinois State Geological Survey, 2 p.

Wehran Engineering, 1987, Summary Report of the Sampling Activities at the Lenz Oil Service Site, prepared for IEPA, dated March 5, 1987.

Willman, H.B., 1971, Summary of the Geology of the Chicago Area, Illinois State Geological Survey Circular 460, 77 p.

Willman, H.B.; Atherton, E.; Buschbach, T.C.; Collinson, C.; Frye, J.C.; Hopkins, N.E.; Lineback, J.A.; and Simon, J.A.; 1975, Handbook of Illinois Stratigraphy, Illinois State Geological Survey Bulletin 95, 261 p.

Willman, H.B. and Lineback, J.A., 1970, "Surficial Geology Map of the Chicago Region," in Summary of the Geology of the Chicago Area. Illinois State Geological Survey Circular 460, 77 p.

Zeizel, A.T.; Walton, W.C.; Sasman, R.T.; and Prickett, T.A.; 1962, Ground Water Resources of DuPage County, Illinois; Illinois State Water Survey and Illinois State Geological Survey Cooperative Ground Water Report 2.

**TABLE 2-1
VERTICAL JOINT ORIENTATION MEASUREMENTS**

Lenz Oil Service, Inc. Site
Lemont, Illinois

Page 1 of 2

Joint Azimuth	All Outcrops	Outcrops #1-#5 ⁽¹⁾	Outcrops #6 and #7 ⁽²⁾
0-5°	1	1	
5-10°	1	1	
10°-15°	3	2	1
15-20°	3	1	2
20-25°	5	3	2
25-30°	2	2	
30-35°	3	2	1
35-40°	4	3	1
40-45°	11	6	5
45-50°	24	15	9
50-55°	20	15	5
55-60°	19	16	3
60-65°	6	5	1
65-70°	1	1	
70-75°	1		1
75-80°			
80-85°	1	1	
85-90°			
90-95°	2	2	
95-100°	1	1	

**TABLE 2-1
VERTICAL JOINT ORIENTATION MEASUREMENTS**

Lenz Oil Service, Inc. Site
Lemont, Illinois

Page 2 of 2

Joint Azimuth	All Outcrops	Outcrops #1-#5 ⁽¹⁾	Outcrops #6 and #7 ⁽²⁾
100-105°	2	2	
105-110°	5	4	1
110-115°	5	4	1
115-120°	19	14	5
120-125°	23	15	8
125-130°	17	8	9
130-135°	29	12	17
135-140°	29	11	18
140-145°	24	12	12
145-150°	7	3	4
150-155°	5	3	2
155-160°	1	1	
160-165°	1		1
165-170°			
170-175°	1		1
175-180°	2	1	1
Total	278	167	111

Notes:

⁽¹⁾ Outcrops #1 through #5 are located near the Calumet Sag Channel and may have been disturbed by construction activities.

⁽²⁾ Outcrops #6 and #7 are located away from the Calumet Sag Channel and are probably undisturbed.

**TABLE 2-2
WATER LEVEL MEASUREMENTS**

Lenz Oil Service, Inc. Site
Lemont, Illinois

Well No.	T.O.C.	B.H.	W.L. 3/20/91	W.L. 2/26/91	W.L. 1/29/91	W.L. 1/6/88	W.L. 3/2/88	W.L. 6/4/86	W.L. 5/28/86
G101M	612.05	588.42	16.51(595.54)	16.30(595.75)	17.47(594.58)	17.88(594.17)	17.64(594.41)	18.90(593.15)	18.32(593.73)
G101L	611.25	570.25	15.41(595.84)	17.10(594.15)	17.67(593.31)	17.12(594.13)	16.89(594.36)	17.90(593.35)	17.64(593.61)
G101D	610.98	576.63	15.41(595.57)	16.34(594.64)	16.72(594.53)	16.98(594.00)	16.81(594.17)	--- (---)	17.52(593.46)
G102L	601.63	584.93	8.02(593.61)	9.65(591.98)	10.24(591.39)	9.54(592.09)	9.64(591.99)	11.10(590.53)	10.18(591.45)
G102D	602.41	580.89	8.98(593.43)	10.60(591.81)	11.18(591.23)	10.50(591.91)	10.60(591.81)	11.90(590.51)	--- (---)
G104L	602.60	+592.1	3.22(599.38)	4.73(597.87)	Frozen(---)	6.09(596.51)	5.72(596.88)	7.30(595.30)	6.07(596.53)
G104D	602.38	586.98	7.03(595.35)	8.04(594.34)	8.40(593.98)	8.53(593.85)	8.48(593.90)	7.50(594.88)	9.14(593.24)
G105S	Damaged	---	Abandoned	Damaged	Damaged(---)	9.59(---)	Damaged(---)	Not Installed	Not Installed
G105D	602.56(?)	+568.7	Abandoned	6.94(595.62)	Damaged(---)	5.45(597.11)	8.27(594.29)	Not Installed	Not Installed
G106S	603.08	+588.58	6.87(596.21)	9.54(593.54)	11.66(591.42)	11.92(591.16)	Dry?(-588)	Not Installed	Not Installed

Notes: T.O.C. = Top of Casing Elevation.
B.H. = Bottom of Hole Elevation.
W.L. = Water Level Depth/Elevation.
--- = No Data Collected.

TABLE 3-1

LENZ OIL SERVICE, INC.
1980-1981 WASTE STREAM

<u>Waste Types Accepted</u>	<u>Approximate Volumes Handled</u>
Waste Oils	6,000 - 10,500 gallons/day
-Motor oil	
-Hydraulic oil	
-Cutting oil	
-Lubricating oils	
-Transformer oil	
Spent Solvents	5,000 gallons/month
-Chlorinated solvents	
-Oxygenated solvents	
-Methyl ethyl ketone	
-Toluol	
-Ethanol	
-Hexane	
-Heptane	
-Acetate	
-Alcohol	
-Zylol	
-Other nonchlorinated solvents	
Pigments	
Inks	

Source: Letters from Charles Russell to IEPA, dated 12-10-80 and 3-31-81.

TABLE 3-2

**LENZ OIL SERVICE, INC.
NON-WASTE MATERIALS STORED ON SITE**

<u>Material</u>	<u>Approximate Volume</u>
Asphalt	1,000 gallons
Diesel	----
Gasoline	----

Source: Letter from Charles Russell to IEPA, dated
12-10-80.

TABLE 3-3

LENZ OIL SERVICE, INC.
1984 WASTE STREAMWaste Types AcceptedApproximate Voumes Handled

Hazardous waste	33,820 gallons/year
Nonhazardous waste	582,444 gallons/year
Petroleum hydrocarbons	
Aliphatic hydrocarbons	
Aromatic hydrocarbons	
Chlorinated hydrocarbons	
Methylene chloride	
Trichloroethylene	
Alcohol	
Naptha	
Acetone	
1,1,1-Trichloroethylene	
Toluene	
Xylene	
Kerosene	
Aliphatic Napthas	
Aromatic Napthas	
Methyl ethyl ketone	
Ethyl acetate	
Butanol	

Source: IEPA report dated 1-17-85.

TABLE 3-4

LENZ OIL SERVICE, INC.
TOTAL REPORTED WASTE STREAM THROUGH 5/24/86

<u>Waste Types Accepted</u>	<u>Approximate Volumes Handled (Gallons/Year)</u>
Waste solvents and ink	137,470
Waste solvents, inks and oils	13,320
Waste solvents	50,015
Waste automobile oil	2,752,792
Waste oil & water	68,514
Other waste oils	26,536
Soil contaminated with #5 fuel oil	<u>2,020</u>
Total	3,098,371

Source: IEPA report, dated 5-24-86.

**TABLE 3-5
LENZ OIL SITE**

AERIAL PHOTOGRAPH INFORMATION

Figure	Date	Approximate Photograph Scale	Film Type	Photo Source
3-4	October 7, 1954	1" = 333'	B & W ⁽¹⁾	ASCS ⁽²⁾
3-5	September 6, 1961	1" = 333'	B & W	ASCS
3-6	September 30, 1967	1" = 333'	B & W	ASCS
3-7	May 14, 1971	1" = 333'	B & W	ASCS
3-8	October 10, 1974	1" = 333'	B & W	ASCS
3-9	November 7, 1981	1" = 750'	B & W	ASCS
3-10	April 12, 1988	1" = 333'	B & W	ASCS

⁽¹⁾ B & W : Black and White.

⁽²⁾ ASCS : U.S. Department of Agriculture, Agriculture
Stabilization and Conservation Service,
Salt Lake City, Utah.

TABLE 4-1

REPORTED CONTAMINANTS IN LENZ OIL DRUMS,
TANKS, AND TANK TRUCKS

<u>Contaminant</u>	<u>Range of Concentrations Detected</u>			
Antimony	<0.5	-	26.2	mg/kg
Aroclor 1016	<5.0	-	25.0	mg/kg
Aroclor 1242	<5.0	-	85.0	mg/kg
Aroclor 1248	<5.0	-	62.0	mg/kg
Aroclor 1260	<5.0	-	26.0	mg/kg
Arsenic	0.35	-	33.94	mg/kg
Barium	<200	-	1020.0	mg/kg
Beryllium	<2.0	-	2.5	mg/kg
Cadmium	<20	-	30.0	mg/kg
Chromium	<20	-	1235.0	mg/kg
Copper	<10	-	345.0	mg/kg
Cyanide, Reactive	<5	-	349.0	mg/kg
Cyanide, Total	<5	-	165.0	mg/kg
Lead	<4.6	-	2030.0	mg/kg
Mercury	<1.0	-	4.06	mg/kg
Nickel	<1.9	-	350.0	mg/kg
PCBs, Total	<5	-	85.0	mg/g
Selenium	<0.6	-	0.14	ug/l
Zinc	<20.0	-	6310.0	mg/kg
Naphthalene	N/A	-	9100.0	ug/g
Methyl Naphthalene	N/A	-	4700.0	ug/g
Dimethyl Naphthalene	N/A	-	3000.0	ug/g
Trimethyl Naphthalene	N/A	-	1920.0	ug/g
Anthracene	N/A	-	510.0	ug/g
1,1-dichloroethane	N/A	-	93.0	ug/g
1,1,1-Trichloroethane	N/A	-	11,000.0	ug/g
Trichloroethylene	N/A	-	5,100.0	ug/g
Benzene	N/A	-	16,000.0	ug/g
Tetrachloroethylene	N/A	-	7,900.0	ug/g
Toluene	N/A	-	45,000.0	ug/g
Ethyl Benzene	N/A	-	33,000.0	ug/g
Xylene	N/A	-	77,100.0	ug/g
Phenol	N/A	-	54,000.0	ug/l
2,4-dimethylphenol	N/A	-	4,800.0	ug/l

NOTE: N/A - Not Available

TABLE 4-2

**REPORTED CONTAMINANTS IN SURFACE IMPOUNDMENTS
(ALL RESULTS IN mg/Kg)**

<u>Parameter</u>	<u>Flow from Surface Impoundment</u>	<u>Surface Impoundment</u>
Organics and PCBs		
Phenol Ethanone	51	23
Aliphatic Acids	92	< 0.5
Aliphatic Acid Esters	55	< 0.5
Cyclohexanone	57	< 0.5
Other Organic Compounds	400	150
Phenol	27	54
2,4-Dimethylphenol	< 0.5	4.8
Methyl Phenol	Trace	7.9
Phenoxy Ethanol	150	93
Methyl Benzene Methanol	600	340
Benzene Ethanol	130	69
Methyl Benzene Ethanol	230	120
Butoxy Ethanol	130	57
Butoxy Ethoxy Ethanol	190	38
Ethoxy Butoxy Ethoxy Ethanol	79	63
Other Aliphatic Alcohols	220	640
PCBs	< 0.05	0.0003
Metals		
Chromium	0.06	ND
Copper	ND	0.05
Iron	8.4	5.3
Lead	ND	0.28
Manganese	5.44	ND
Mercury	0.00406	0.00218
Zinc	ND	2.8

Note: ND = Not Detected

TABLE 4-3
 REPORTED CONTAMINANTS IN ON SITE SOILS
 (Page 1 of 3)

Parameter	Concentration Range
<u>Metals</u>	<u>(mg/kg)</u>
Aluminum	NA - 37960
Antimony	<0.006
Arsenic	<2.09 - 14.3
Barium	<200 - 3250
Beryllium	<0.091 - 2.64
Cadmium	<0.054 - 8.57
Chromium	<0.008 - 43.6
Cobalt	<10 - 11.3
Copper	<5 - 62.1
Iron	N/A - 33800
Lead	N/A - 1250
Maganese	N/A - 835
Mercury	<0.01 - 0.14
Nickel	<0.36 - 35.8
Selenium	<0.25 - 0.66
Silver	<0.18 - 7.97
Thallium	<0.17 - 3.9
Varadium	<10 - 81.2
Zinc	N/A - 440
 <u>Volatile Organics</u>	 <u>(ug/kg)</u>
1,1-Dichloroethane	<5 - 68000
Trans - 1,2Dichlroethene	<5 - 80000
2-Butanone	<10 - 2800
1,1,1-Trichloroethane	<5 - 85000

TABLE 4-3
REPORTED CONTAMINANTS IN ON SITE SOILS
(Page 2 of 3)

Trichloroethene	<5 - 140000
Benzene	<5 - 8500
4-Methyl-2-pentanone	<10 - 15000
Tetrachloroethene	<5 - 32000
Toluene	<5 - 890000
Ethylbenzene	<5 - 26000
Total Xylenes	<5 - 2000000

Semi-Volatile Organics

(ug/kg)

1,2-Dichlorobenzene	<330 - 34000
4-Methylphenol	<330 - 11000
Isophorone	<330 - 9200
2,4-Dimethylphenol	<330 - 5000
Naphthalene	<330 - 30000
2-Methylnaphthalene	<330 - 65000
Acenaphthlene	<330 - 2400
Phenol	<330 - 10000
Dibenzofuran	<330 - 1700
Fluorene	<330 - 3500
Phenanthrene	<330 - 12000
Anthracene	<330 - 2100
Di-n-butylphthalate	<330 - 3500
Fluoranthene	<330 - 7500
Pyrene	<330 - 5500
Butylbenzylphthalate	<330 - 2400
Benzo(a)anthracene	<330 - 3300
Chrysene	<330 - 3400
bis(2-Ethylhexyl)phthalate	<330 - 27000

TABLE 4-3
REPORTED CONTAMINANTS IN ON SITE SOILS
(Page 3 of 3)

Benzo(b)fluoranthene	<330 - 2500
Benzo(a)pyrene	<330 - 2300
Indeno(1,2,3-cd)pyrene	<330 - 1300
Benzo(g,h,i)perylene	<330 - 1800

TABLE 4-4
REPORTED CONTAMINANTS IN
INCINERATOR ASH

<u>Analyte</u>	<u>Concentration Range (ug/lg)</u>
Isophorone	<115 - 1800
Naphthalene	< 115
2-Methylnaphthalene	<1,000
Phenanthrene	<1,000
Pyrene	< 115
bis (2-ethylhexyl) phthalate	<1,000
Fluoranthene	< 115

Note: No volatile organic analysis available.

TABLE 4-5
REPORTED CONTAMINATION IN TENT SAMPLES

Parameter	Detection Limits (ug/kg)	Max. Detected Concentration (ug/kg)
Isophorone	20000	12000J
Naphthalene	20000	35000
2-Methylnaphthalene	20000	36000
Acenaphthlene	20000	4400J
Dibenzofuran	20000	4200J
Fluorene	20000	5600J
Phenanthrene	20000	17000J
Anthralene	20000	3100J
Di-n-butylphthalane	20000	1800J
Fluoranthene	20000	7900J
Pyrene	20000	9200J
Butylbenzlpthalate	5000	490J
Benzo(a)anthracene	20000	3400J
Chrysesne	20000	3400J
bis(2-Ethylhexyl)phthalate	20000	17000JB

Notes:

(1) J - Indicates that the compound was analyzed for and detected at concentrations below the detection limit. The reported value is estimated.

B - The analyte was also found in the blank.

TABLE 4-6

PRIVATE WELL SAMPLING PARAMETERS

<u>RESIDENCE</u>	<u>ADDRESS</u>	<u>METALS</u>	<u>NITRATES</u>	<u>VOLATILES</u>	<u>SEMI-VOLATILES</u>	<u>PCBs/PEST.</u>	<u>CYANIDE</u>
Schuster	11 S. 305 Jackson Street	X	X	X	X	X	X
Gruber	Jeans Road	X	X	X	X	X	X
Williams	Jeans Road	X	X	X	X	X	X
Kempa	16 W 415 99th Street			X	X	X	
Flaks	97th Street			X	X	X	
Lenz	Route 2, Box 208	X	X	X	X	X	X
Mason	Jeans Road	X	X				
Stein Haus	Not Recorded	X					
Knowlwood	Not Recorded	X					

TABLE 4-7

REPORTED CONTAMINANTS IN PRIVATE WELLS
(ALL RESULTS IN mg/l)

	<u>RESIDENCE/SAMPLING DATE</u>						
	<u>WILLIAMS</u> <u>(11/6/86)</u>	<u>BOWLES</u> <u>(11/6/86)</u>	<u>GRUBER</u> <u>(11/6/86)</u>	<u>MASON</u> <u>(11/6/86)</u>	<u>WILLIAMS</u> <u>(3/5/85)</u>	<u>WILLIAMS</u> <u>(6/3/87)</u>	<u>WILLIAMS</u> <u>(7/29/86)</u>
<u>Metals</u>							
Barium	0.080	<0.050	<0.050	<0.050	<0.1	0.063	N/A
Chromium	0.015	<0.010	0.013	<0.010	N/A	N/A	N/A
Copper	0.173	2.99	0.052	0.021	N/A	N/A	N/A
Iron	2.03	0.257	0.563	2.13	1.80	1.55	N/A
Lead	0.008	0.021	0.008	0.005	<0.05	1.55	N/A
Manganese	0.048	0.022	0.038	0.072	<0.04	0.007	N/A
Silver	0.070	0.188	0.040	0.011	<0.010	0.016	N/A
Vanadium	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	N/A
Zinc	0.110	0.585	0.239	0.053	<0.010	0.056	N/A
<u>Volatile Organics</u>							
Acetone	<0.005	<0.005	0.012	<0.005	0.710	<0.005	<0.005
Chloroethane	<0.005	<0.005	<0.005	<0.005	Trace	0.011	0.010
Benzene	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005
Ethylbenzene	<0.005	<0.005	<0.005	<0.005	Trace	<0.005	<0.005
Xylene	<0.005	<0.005	<0.005	<0.005	Trace	<0.005	<0.005

Note: N/A = Not Applicable

TABLE 4-8

REPORTED CONTAMINANTS IN LENZ OIL GROUND WATER

<u>Contaminant</u>	<u>Range of Concentrations Detected</u>		
Chloroethane	<10	-	112.0 ug/l
C-1,2dichloroethene	<5	-	460.0 ug/l
1,2-dichloroethane	<5	-	215.0 ug/l
1,1,1-trichloroethane	<5	-	252.0 ug/l
Benzene	<5	-	110.0 ug/l
Vinyl Chloride	<10	-	22.0 ug/l
Tetrachloroethene	<5	-	7.4 ug/l
1,1-dichloroethane	<5	-	200.0 ug/l
Toluene	<5	-	1,000.0 ug/l
2-butanone(methyl ethyl ketone)	<10	-	13,700.0 ug/l
Ethylbenzene	<5	-	43.0 ug/l
Xylene, Total	<5	-	180.0 ug/l
PCBs, Total	N/A		200.0 ug/l
Naphthalene	<10	-	13.0 ug/l
Methyl Naphthalene	<10	-	47.0 ug/l
Dimethyl Naphthalene	N/A		100.0 ug/l
Trimethyl Naphthalene	N/A		80.0 ug/l
Anthracene	<10	-	45.0 ug/l
1,2-dichloroethylene	<5	-	61.0 ug/l
Isophorone	<10	-	32.0 ug/l
Phenol	<10	-	Trace ug/l

NOTE: N/A - Not Applicable

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
1		38N	11E	36 (SE)	15 W 218 87TH ST.(SE,SW,SE)	BURR OAK DEVL.	6/13/89	220	OPEN	106-220	99	ROCK
2	26532	38N	11E	36 (SE)	5025 S. SEELEY (SW,SE,SE)	ROBERT NERI	4/24/81	180	OPEN	90-180	100	LIMESTONE
3	2910	38N	11E	36 (SW)	JAROS RESUB LOT #4	RELIABLE CONST.	7/27/72	170	OPEN	146-170	100	ROCK
4	1723	38N	11E	35 (SE)	DOWNER'S GROVE TWP. (SE,SE,SE)	TORRICK	1941	160	OPEN?	114-160		ROCK
5	23670	38N	11E	35 (SE)	9 S 666 MEADOWBROOK DR.	RELIABLE CONST.	3/20/74	170	OPEN	148-170	48	LIMESTONE
6	27892	38N	11E	35 (SE)	8421 MEADOWBROOK DR.	RICHARD PATTON	8/3/87	240	OPEN	154-240	140	LIMESTONE
7	28261	38N	11E	35 (SE)	10 S 131 LEONARD (SE,SE,SE)	HAMLET STEPHENS	8/20/88	190	OPEN	125-190	50	LIMESTONE
8		38N	11E	35 (SW)	8425 MEADOWBROOK (LOT #10)	GENE VINEYARD	8/10/76	150	OPEN		119	LIMESTONE
9	960	38N	11E	35 (SW)	TLE #66 (S/2,SW,SW)	JOHN HUINER	1/29/68	180	OPEN?	138-180	75	LIMESTONE
10	1717	38N	11E	35 (SW)	TRI-STATE VILLAGE (E/2,SW)	CASINO BELLOTA	1948	25	CEMENT	10-25		SAND/CLAY
11	1719	38N	11E	35 (SW)	(TSV) 279 ROSE ST.(E/2,SW)	STANLEY FRYZA	1948	36	CEMENT	10-36		SAND
12	1720	38N	11E	35 (SW)	(TSV) 407 JANET AVE.(E/2,SW)	LESTER LARSON	1948	26	CEMENT	10-26		SAND/CLAY
13	1721	38N	11E	35 (SW)	(TSV) JANET AVE.(E/2,SW)	FRANK POLKA	1948	32	CEMENT	10-32		SAND
14	1798	38N	11E	35 (SW)	(TSV) LOT #8 (SE,SW)	TSV DEVELOPMENT	1941	206	OPEN?	136-206		LIMESTONE
15	2910	38N	11E	35 (SW)	JAROS RE-SUB.	RELIABLE CONST.	3/7/72	170	OPEN	146-170	100	ROCK
16	24482	38N	11E	35 (SW)	TLE LOT #70 (SW,SW)	THOMAS JANSKY	11/25/75	220	OPEN	120-220	120	LIMESTONE
17	24589	38N	11E	35 (SW)	(TSV) LOT #1 (E/2,SW)	JOSEPH GAREST, JR.	6/22/76	165	OPEN	112-165	85	LIMESTONE
18	24812	38N	11E	35 (SW)	TIMBERLAKE ESTATES LOT #62	PARRISH CONST.	9/15/76	160	OPEN	125-160	28	LIMESTONE
19	25811	38N	11E	35 (SW)	9 S 750 WILLIAM DR.(SE,SW,SW)	HENRY PAETSCH	9/23/76	235	OPEN?	180-235	85	LIMESTONE
20	26526	38N	11E	35 (SW)	8627 MEADOWBROOK (SW,NW,SE)	CLIFF WARTHEN	8/2/80	205	OPEN	141-205	129	LIMESTONE
21	26527	38N	11E	35 (SW)	9 S 274 BROOKBANK (SW,SW,SW)	CHARLES ZAK	6/24/82	220	OPEN	122-220	79	LIMESTONE
22	27078	38N	11E	35 (SW)	17 W 155 W.87TH (TLE #81)	GEORGE SKUNDRNA	6/24/85	200	OPEN	150-200	99	LIMESTONE
23	28299	38N	11E	35 (SW)	207 BONNIE BRAE (SW,SE,SW)	CHRIS SALAMOUSKI	10/4/88	185	OPEN	108-185	89	LIMESTONE
24	3105	38N	11E	34 (E/2)	TLE LOT #81 (E/2,E/2)	JAS RAY	2/13/73	180	OPEN	108-180	100	ROCK
25	3366	38N	11E	34 (E/2)	(TLE #8) 7946 TENNESSEE(E/2,E/2)	FRANK ZELIP	9/15/73	180	OPEN	106-180	100	LIMESTONE
26	24358	38N	11E	34 (E/2)	8220 CLARENDON HILLS RD.	RICHARD CECHOWSKI	10/15/75	190	OPEN	130-190	80	LIMESTONE
27		38N	11E	34 (SE)	NW 16 FRONTAGE RD.(SE,SE,SE)	ART SALLNER?	10/9/74	165	OPEN	94-165	74	LIMESTONE
28		38N	11E	34 (SE)	TIMBER LAKE ESTS. LOT #47	PARRISH CONST.	2/15/72	140	OPEN	120-140	58	ROCK
29		38N	11E	34 (SE)	350 MEADOW CT. (TLE #67)	MIKE YAO	9/9/75	160	OPEN	115-160	83	LIMESTONE
30	84	38N	11E	34 (SE)	DU PAGE CO. (SW,SW,SE)	A.F. BUILDERS	1957	170	OPEN	112-170	58	LIMESTONE
31	85	38N	11E	34 (SE)	DU PAGE CO.(SE,SE)	A.F. BUILDERS	1955	185	OPEN	145-185	75	LIMESTONE
32	2280	38N	11E	34 (SE)	9 S 580 CLARENDON HILLS(NE,SE,SE)	KETTLE CONST.	10/20/71	127	STL CAS?	100-127	89	GRAVEL
33	24254	38N	11E	34 (SE)	(TLE) 9 S 709 LORRAINE (SE,SE)	ROBERT ZINTAK	10/7/75	180	OPEN	138-180	108	LIMESTONE
34	24809	38N	11E	34 (SE)	(TLE)9 S 642 LORRAINE(S/2,SE,SE)	ACCURATE DESIGN	9/13/76	200	OPEN	148-200	80	LIMESTONE
35	26518	38N	11E	34 (SE)	(TLE LOT #47) 8015 ALABAMA	ALBERT SUCHA	10/19/79	195	OPEN	123-195	100	LIMESTONE

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
36	26519	38N	11E	34 (SE)	(TLE) 8035 TENNESSEE (NW,NE,SE)	ROBERT SVATEK	10/9/80	185	OPEN	116-185	84	LIMESTONE
37	26525	38N	11E	34 (SE)	8425 MEADOWBROOK DR.	GENE VINEYARD	4/1/76	220?	OPEN	150-220?	119	LIMESTONE
38		38N	11E	34 (SW)	1033 FRONTAGE RD. (SW,SE,SW)	CHESTER GASAWAY	2/24/84	200	OPEN	97-200	79	LIMESTONE
39	905	37N	12E	6 (NW)	87TH & COUNTY LINE RD.(NW,NE,NW)	CATALINA CONST.	3/2/68	160	OPEN	84-160	36	LIMESTONE
40	25841	37N	12E	6 (NW)	8901 COUNTY LINE RD.(SW,NW,NW)	WILLIAM JOHNSTON	11/23/77	160	OPEN	103-160	98	LIMESTONE
41	29367	37N	12E	6 (NW)	NE 1/4 OF SW 1/4 OF NW 1/4	GEORGE MATOCHA	8/19/79	140	OPEN	90-140	58	LIMESTONE
42	29368	37N	12E	7 (NW)	133 E. OGDEN AVE.? (NW,NW)	ROWELL CHEMICAL	10/13/83	100	OPEN	40-100	8?	LIMESTONE
43	25394	37N	12E	7 (SW)	FOREST PRESERVE (NW,NW,SW)	ARGONNE LAB	9/23/76	173	OPEN	128-173	140	LIMESTONE
44	25395	37N	12E	7 (SW)	FOREST PRESERVE (NW,NW,SW)	ARGONNE LAB	9/28/76	280	OPEN	116-280	99	LS/SHALE
45	25396	37N	12E	7 (SW)	FOREST PRESERVE (NW,NW,SW)	ARGONNE LAB	9/20/76	201	OPEN	160-201	98	LIMESTONE
46	2144	37N	12E	18 (NW)	U. OF C. EXP. STA. (NW,NW,NW)	IL WATER SURVEY	1/44	308	OPEN	171-308	153	LIMESTONE
47	25397	37N	12E	18 (NW)	FOREST PRESERVE (NW,NW,NW)	ARGONNE LAB	9/17/76	215	OPEN	175-215	160	LIMESTONE
48		37N	11E	1 (NE)	11519 ROSEMER (NE,NE,NE)	EDWARD OTTO	11/28/69	180	OPEN	100-180	115	LIMESTONE
49		37N	11E	1 (NE)	87TH ST. S. OF HINSDALE (SW,NE)	ED MALICK		150	OPEN	56-150		ROCK
50		37N	11E	1 (NE)	15 W 051 87TH (NE,NW,NE)	CARL LAUDONDO	11/18/83	185	OPEN	77-185	59	LIMESTONE
51		37N	11E	1 (NE)	15 W 620 89TH (SW,NW,NE)	VAL ADAMKUS	10/2/79	220?	OPEN	133-220?	136	LIMESTONE
52	1111	37N	11E	1 (NE)	CVE (NE,SE,NE)	TERRY HECTOR	1/30/68	71	OPEN	44-71	18	LIMESTONE
53	1118	37N	11E	1 (NE)	CVE #33 (E/2,NE)	TERRY HECTOR	5/68	80	OPEN	52-80	31	SHALE?
54	1119	37N	11E	1 (NE)	CVE #20 (E/2,NE)	TERRY HECTOR	5/68	80	OPEN	52-80	21	SHALE?
55	1120	37N	11E	1 (NE)	CVE #1 (E/2,NE)	TERRY HECTOR	5/68	75	OPEN	48-75	24	SHALE?
56	1121	37N	11E	1 (NE)	CVE #44 (E/2,NE)	TERRY HECTOR	5/68	79	OPEN	42-79	27	SHALE?
57	1122	37N	11E	1 (NE)	CVE #38 (E/2,NE)	TERRY HECTOR	5/68	75	OPEN	46-75	26	SHALE?
58	1123	37N	11E	1 (NE)	CVE #18 (E/2,NE)	TERRY HECTOR	6/68	80	OPEN	46-80	28	LIMESTONE
59	1564	37N	11E	1 (NE)	SE 1/4 OF SW 1/4 OF NE 1/4	KOTELLA		120	OPEN?	75-120?		ROCK
60	3430	37N	11E	1 (NE)	NE 1/4 OF SE 1/4 OF NE 1/4	DIORIO BLDRS.	10/18/73	213	OPEN	80-213	59	ROCK
61	23693	37N	11E	1 (NE)	11 S 420 DREW (NW,NE,NE)	RICHARD SOMOLIK	1/7/74	113	OPEN	74-113	19	LIMESTONE
62	23863	37N	11E	1 (NE)	15 W 101 87TH ST.(NE,NE,NE)	RONALD CHOCHOLA	9/23/74	200	OPEN	70-200	60	LIMESTONE
63	23908	37N	11E	1 (NE)	15 W 101 87TH ST.(NE,NE,NE)	RONALD CHOCHOLA	12/4/74	160	OPEN	68-160	60	LIMESTONE
64	24228	37N	11E	1 (NE)	8750 S. COUNTY LINE(SW,NW,NE)	JOHN PARTEPELO	7/22/75	200	OPEN	60-200	38	ROCK
65	25015	37N	11E	1 (NE)	NW 1/4 OF SE 1/4 OF NE 1/4	PAT ALDERTINI	12/2/76	205	OPEN	136-205	138	LIMESTONE
66	25220	37N	11E	1 (NE)	15 W 101 87TH ST.(NE,NE,NE)	RONALD CHOCHOLA	11/2/78	180	OPEN	60-180	98	LIMESTONE
67	28428	37N	11E	1 (NE)	15 W 305 91ST ST. (S/2,NE)	CAM KRAUSE	7/20/84	200	OPEN	97-200	70	LIMESTONE
68		37N	11E	1 (NW)	8900 S. MADISON (NW,SW,NW)	EDWARD PRINER	1/4/82	200	OPEN	126-200	60	ROCK
69		37N	11E	1 (NW)	15 W 620 89TH ST (PAYNE'S #1)	RICHARD REDIEHS	9/10/79	220	OPEN	125-220	130	LIMESTONE

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN- SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
70	2129	37N	11E	1 (NW)	SPACE VALLEY SUBD. LOT #19	CHATEAU HOMES	6/28/71	130	OPEN	100-130	70	ROCK
71	3128	37N	11E	1 (NW)	10 S 245 MADISON ST.(NW,SW,NW)	G. RODRIGUEZ	3/3/73	180	OPEN	120-180	130	LIMESTONE
72	3480	37N	11E	1 (NW)	OAKDALE LOT #19 (SW,NW)	JACK WHEELER	11/5/73	200	OPEN	130-200	112	ROCK
73	25221	37N	11E	1 (NW)	(OD #37)10 S 230 GRANT(NE,SW,NW)	GARY HERMES	8/24/78	188	OPEN	120-188	120	LIMESTONE
74	25222	37N	11E	1 (NW)	ERICKSON MANOR SUBD. LOT #1	PONSTERN BLDRS.	10/31/78	190	OPEN	110-190	38	LIMESTONE
75	27169	37N	11E	1 (NW)	15 W 720 89TH ST. (SW,NW,NW)	WILLIAM NORRIS	11/5/85	250	OPEN	126-250	125	LIMESTONE
76		37N	11E	1 (SE)	87TH ST. S. OF HINSDALE (NW,SE)	WILLIAM WASHER		120	OPEN	94-120		ROCK
77		37N	11E	1 (SE)	87TH ST. S. OF HINSDALE (SW,SE)	CRADDEVILL		54	OPEN	40-54		ROCK
78	1565	37N	11E	1 (SE)	W/2 OF NE 1/4 OF SE 1/4	JOHN RACEK	5/37	160	OPEN?	60-160	60	SIL DOL
79		37N	11E	1 (SW)	1818 S. CLARENCE (OAK RIDGE #3)	TONY SARACCO	8/26/82	200	OPEN	124-200	69	ROCK
80	1032	37N	11E	1 (SW)	10 S 441 MADISON ST.(NW,NW,SW)	KETTEL CONST.	5/14/68	140	OPEN	105-140	94	LIMESTONE
81	1061	37N	11E	1 (SW)	10 S 445 GLENN (SV LOT #3)	SEFARA BLDRS.	11/15/68	160	OPEN	85-160	50	LIMESTONE
82	1185	37N	11E	1 (SW)	SPACE VALLEY LOT #1	SEFARA BLDRS.	5/10/69	160	OPEN	100-160	90	LIMESTONE
83	1241	37N	11E	1 (SW)	SPACE VALLEY LOT #4	SEFARA BLDRS.	10/15/69	160	OPEN	100-160	80	LIMESTONE
84	2033	37N	11E	1 (SW)	10 S 580 GLENN DR.(SW,NW,SW)	SEFARA BLDRS.	5/24/71	180	OPEN	85-180	65	ROCK
85	2120	37N	11E	1 (SW)	91ST & MADISON (NW,NW,SW)	THOMAS BEURSKEN	7/3/71	170	OPEN	110-170	59	ROCK
86	2130	37N	11E	1 (SW)	SPACE VALLEY #6 (NW,SW,SW)	SEFARA BLDRS.	7/27/71	265	OPEN	133-265	138	ROCK
87	2309	37N	11E	1 (SW)	(AD#40)11 S 344 MADISON(W/2,SW)	ROBERT NEWMAN	11/23/71	130	OPEN	45-130	10	LIMESTONE
88	2430	37N	11E	1 (SW)	10 S 607 GLENN DR. (NW,SW,SW)	KETTEL CONST.	3/22/72	165	OPEN	120-165	104	LIMESTONE
89	2472	37N	11E	1 (SW)	SW 1/4 OF SW 1/4 OF SW 1/4	RELIABLE CONST.	4/28/72	120	OPEN	105-120	78	ROCK
90	3129	37N	11E	1 (SW)	(SV #5)10 S 675 GLENN(NW,SW,SW)	SWANSON	3/3/73	190	OPEN	118-190	130	LIMESTONE
91	3228	37N	11E	1 (SW)	SPACE VALLEY SUBD. LOT #31	CASTLE BLDRS.	7/2/73	160	OPEN	100-160	50	ROCK
92	3229	37N	11E	1 (SW)	10 S 581 MADISON ST.(SV #35)	LEROY SKRIDEN	5/25/73	180	OPEN	116-180	110	LIMESTONE
93	3431	37N	11E	1 (SW)	NORTH 100', LOT #61	RELIABLE CONST.	7/22/73	135	OPEN	120-135	53	LIMESTONE
94	3479	37N	11E	1 (SW)	SPACE VALLEY LOT #20	PAUL SMITH	11/6/73	160	OPEN	102-160	115	LIMESTONE
95	24318	37N	11E	1 (SW)	15 W 531 89TH (SW,SE,SW)	STEVENS BLDRS.	10/16/75	190	OPEN	125-190	80	LIMESTONE
96	24579	37N	11E	1 (SW)	SPACE VALLEY SUBD. LOT #32	ALEX MCCrackEN	5/17/76	180	STL CAS?	0-180	58	LIMESTONE
97	24747	37N	11E	1 (SW)	SE 1/4 OF NE 1/4 OF SW 1/4	DAVE ERICKSON	10/15/76	150	OPEN	90-150	60	LIMESTONE
98	24748	37N	11E	1 (SW)	(SV #2)10 S 526 GLENN(SW,NW,SW)	DONALD HALL	11/3/76	185	OPEN	130-185	130	LIMESTONE
99	25093	37N	11E	1 (SW)	SANITARY DIST. (AD LOT #61)	EDWARD McCLUSKY	5/27/77	190	OPEN	126-190	75	LIMESTONE
100	25094	37N	11E	1 (SW)	(SV #11)9532 HENNITTA(W/2,SW)	CARL RUMER	5/27/77	180	OPEN	126-180	78	LIMESTONE
101	25949	37N	11E	1 (SW)	NW 1/4 OF SW 1/4 OF SW 1/4	JOE DePAULO	7/6/79	160	OPEN	103-160	69	LIMESTONE
102	27215	37N	11E	1 (SW)	10 S 601 GARFIELD RD.(NE,NW,SW)	ROBERT BIAGETTI	10/22/85	125	OPEN	66-125	29	LIMESTONE
103	23616	37N	11E	1 (SW?)	ASSESSMENT DIVISION LOT #40	JERUTIS BLDRS.	2/11/74	125	OPEN	41-125	20	LIMESTONE
104	23617	37N	11E	1 (SW?)	ASSESSMENT DIVISION LOT #7	JERUTIS BLDRS.	2/18/74	150	OPEN	80-150	60	LIMESTONE
105	1112	37N	11E	1? (NE)	CVE #27 (SE,SE,NE)	TERRY HECTOR	1/30/68	74	OPEN	46-74	20	LIMESTONE

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
106		37N	11E	2 (NE)	16 W 140 89TH ST.(SE,NW,NE)	GARY KNOLBLOCH	10/12/82	220	OPEN	163-220	119	LIMESTONE
107	897	37N	11E	2 (NE)	9012 SKYLINE DR.(SW,SW,NE)	VIOLA WOLFF	8/14/67	192	OPEN	126-192	108	ROCK
108	1972	37N	11E	2 (NE)	(TSV) SKYLINE DR. (SW,NE)	HAZEL POKALL	1948	34	CEMENT	10-34		SAND/GVL
109	2131	37N	11E	2 (NE)	TSV LOT #13	PARK LANE REALTY	6/27/71	200	OPEN	150-200	78	ROCK
110	2310	37N	11E	2 (NE)	TRI-STATE VILLAGE LOT #12	W. WILLIAMSON	11/23/71	200	OPEN	158-200	88	ROCK
111	2357	37N	11E	2 (NE)	(TSV #24)8915 PALISADES(W/2,NE)	R. ZIMA	11/15/71	225	OPEN	170-225	149	ROCK
112	2963	37N	11E	2 (NE)	TSV LOT #4	BALDUCCI	9/19/72	160	OPEN	143-160	65	ROCK
113	3038	37N	11E	2 (NE)	TSV LOT #3	JOHN BRETZ	11/6/72	195	OPEN	175-195	78	ROCK
114	3211	37N	11E	2 (NE)	TRISTATE VILLAGE LOT #13	BALDUCCI	5/22/73	155	OPEN	118-155	80	ROCK
115	3275	37N	11E	2 (NE)	TSV LOT #5	PHIL BIESEMEYER	6/19/73	180	OPEN	144-180	60	ROCK
116	3276	37N	11E	2 (NE)	TSV LOT #6	PHIL BIESEMEYER	6/19/73	180	OPEN	138-180	60	ROCK
117	23566	37N	11E	2 (NE)	40 CUSTER ST. (NE,SE,NE)	ED JEANS	12/18/73	225	OPEN	137-225	160	LIMESTONE
118	23802	37N	11E	2 (NE)	143 HILLSIDE LANE (NW,NE)	JURE POZEK	8/27/74	220	OPEN	155-220	130	LIMESTONE
119	24059	37N	11E	2 (NE)	TSV LOT #15	EARL CLYDE	4/1/75	180	OPEN	125-180	33	LIMESTONE
120	24060	37N	11E	2 (NE)	8805 PALISADES (TSV #32)	RONALD MAROUSEK	4/2/75	205	OPEN	155-205	125	LIMESTONE
121	24319	37N	11E	2 (NE)	SE 1/4 OF SW 1/4 OF NE 1/4	JZ CONST.	11/20/75	180	OPEN	115-180	80	LIMESTONE
122	24450	37N	11E	2 (NE)	10 S 330 MADISON (SE,SE,NE)	DIORIO BLDRS.	3/29/76	175	OPEN	115-175	130	LIMESTONE
123	24580	37N	11E	2 (NE)	534 OGDEN (TSV LOT #19)	PARK LANE REALTY	5/4/76	180	STL CAS?	0-180	124	LIMESTONE
124	25015	37N	11E	2 (NE)	8700 S. COUNTY LINE (NW,SE,NE)	PAT ALDERTINI	12/2/76	205	OPEN	139-205	138	LIMESTONE
125	25225	37N	11E	2 (NE)	16 W 310 91ST (SW,SW,NE)	R.T. CHADNER	11/15/78	205	OPEN	150-205	115	LIMESTONE
126	25227	37N	11E	2 (NE)	16 W 184 89TH (SW,NE,NE)	LEAHY HOME BLDRS.	11/18/77	250	OPEN	153-250	147	LIMESTONE
127	25228	37N	11E	2 (NE)	10950 URSULA DR.(NW,NE,NE)	ST. & ASSOCS.	12/19/77	165	OPEN	155-165	98	LIMESTONE
128		37N	11E	2 (NW)	8101 COUNTY LINE RD.(W/2,NW)	GEORGE REDIEHS	4/15/77	125	OPEN	40-125	4	LIMESTONE
129		37N	11E	2 (NW)	17 STIRRUP CT. (TLE #47)	ROBERT DELMASTRO	7/18/79	220	OPEN	138-220	118	LIMESTONE
130	24749	37N	11E	2 (NW)	9053 O'NEIL (TLE #15)	RUDY DURHAM	9/30/76	200	OPEN	147-200	85	LIMESTONE
131	3230	37N	11E	2 (NW)	10 S 60 LAKEWOOD (TLE #55)	FRANK GAWEL	5/29/73	190	OPEN	137-190	90	LIMESTONE
132	3101	37N	11E	2 (NW)	TSV LOT #13	TOM FISHER	3/30/73	180	OPEN	160-180	80	ROCK
133	1147	37N	11E	2 (NW)	16 W 466 91ST ST. (S/2,NW)	JOSEPH BOBEK	3/14/69	190	OPEN	150-190	138	LIMESTONE
134	23995	37N	11E	2 (NW)	10 S 070 RTE.83 (NE,NE,NW)	GEORGE MATOCHA	2/5/75	205	OPEN	160-205	100	LIMESTONE
135	23996	37N	11E	2 (NW)	16 W 471 HILLSIDE (SE,NE,NW)	FRANK RUZICKA	2/6/75	205	OPEN	160-205	100	LIMESTONE
136	24750	37N	11E	2 (NW)	16 W 556 HILLSIDE (SE,NE,NW)	MELVIN MILLER	9/16/76	190	OPEN	135-190	80	LIMESTONE
137	83	37N	11E	2 (NW)	NE 1/4 OF SE 1/4 OF NW 1/4	A.J. BUILDERS	1957	175	OPEN	125-175	70	LIMESTONE
138	1062	37N	11E	2 (S/2)	SPACE VALLEY LOT #2	SEFARA BLDRS.	5/23/68	100	STL CAS?	0-100	90	SAND/GRAVEL
139	2356	37N	11E	2 (SE)	SPACE VALLEY LOT #24	CREATIVE BLDRS.	1/19/72	260	OPEN	119-260	88	ROCK
140	2473	37N	11E	2 (SE)	16 W 125 89TH (SE,NE,SE)	JOSEPH DACKA	3/11/72	240	OPEN	142-240	79	ROCK

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
141	2480	37N	11E	2 (SE)	SPACE VALLEY SUBD. LOT #7	BOLT BROS.	5/31/72	126	OPEN	120-126	60	ROCK
142	25224	37N	11E	2 (SE)	NE 1/4 OF SE 1/4 OF SE 1/4	ROBERT BAKER	8/24/77	200	OPEN	147-200	34	ROCK
143	25226	37N	11E	2 (SE)	10 S 934 MADISON (SE,SE,SE)	HANDCRAFTED HOMES	11/28/78	200	OPEN	127-200	115	LIMESTONE
144	27540	37N	11E	2 (SE)	10420 S. KNOX (SW,SE,SE)	ROBERT SWAYKA	1/27/87	180	OPEN	130-180	85	ROCK
145	1161	37N	11E	2 (SE)	CENTER OF NW 1/4 OF SE 1/4	FRED LENZ	7/15/68	205	OPEN	140-205	90	NIAG LS
146	1162	37N	11E	2 (SE)	CENTER OF NW 1/4 OF SE 1/4	WINSTON LENZ	8/1/68	205	OPEN	140-205		NIAG LS
147	2069	37N	11E	2 (SE)	94TH & JACKSON (SW,SW,SE)	RELIABLE CONST.	3/23/71	180	OPEN	162-180	79	ROCK
148	2132	37N	11E	2 (SE)	16 W 375 94TH ST.(SW,SW,SE)	RELIABLE CONST.	7/16/71	180	OPEN	160-180	139	ROCK
149	2474	37N	11E	2 (SE)	16 W 185 89TH ST.(SE,NW,SW)	JOSEPH SERAFIN	5/23/72	240	OPEN	138-240	79	ROCK
150	3039	37N	11E	2 (SE)	OAK HILL ESTATES LOT #14	RELIABLE CONST.	10/27/72	190	OPEN	150-190	28	ROCK
151	3095	37N	11E	2 (SE)	94TH & OAK HILL (OH LOT #9)	NICK BATISTICH	1/19/73	140	OPEN	111-140	89	ROCK
152	3167	37N	11E	2 (SE)	OAK HILL ESTATES LOT #25	RELIABLE CONST.	4/19/73	180	OPEN	166-180	60	ROCK
153	3394	37N	11E	2 (SE)	OAK HILL LOT #19	PARRISH CONST.	10/5/73	160	OPEN	147-160	60	ROCK
154	23618	37N	11E	2 (SE)	16 W 253 94TH ST (OH #12)	JAMES MCGUIRE	12/10/73	200	OPEN	147-200	129	ROCK
155	23694	37N	11E	2 (SE)	16 W 302 W 94TH ST.(SE,NW,SE)	TIM ZANGRI	5/10/74	180	OPEN	137-180	58	ROCK
156	23741	37N	11E	2 (SE)	510 DOWNERS DR.(OAK HILL #7)	NICK BATISTICH	5/24/74	190	OPEN	128-190	75	LIMESTONE
157	23864	37N	11E	2 (SE)	OAK HILL ESTS. LOT #3 (NW,SW,SE)	DENNIS BUMBER	9/6/74	170	OPEN	160-170	78	LIMESTONE
158	24229	37N	11E	2 (SE)	(OH #1) 93RD PLACE (SW,SE)	BLDG. & CONST.	9/23/75	190	OPEN	130-190	115	LIMESTONE
159	27472	37N	11E	2 (SE)	16 W 300 94TH PL.(SE,SW,SE)	NEDELJKO NIHOLIC	8/29/86	205	OPEN	145-205	139	LIMESTONE
160	27473	37N	11E	2 (SE)	382 LORCH (SE,SW,SE)	RICHARD SABLICK	2/12/87	180	OPEN	126-180	79	ROCK
161	27653	37N	11E	2 (SE)	OAK HILL #10 (SW,SW,SE)	WARTHEN PUMP	5/1/87	205	OPEN	153-205	109	LIMESTONE
162	27701	37N	11E	2 (SE)	2650 BREWER LANE (SE,SW,SE)	CALLAHAN & ASSOC.	4/13/87	180	OPEN	120-180	79	ROCK
163	27791	37N	11E	2 (SE)	16 W 267 94TH ST.(SE,SW,SE)	DEBBIE ROCKABRAND	6/3/87	180	OPEN	148-180	79	ROCK
164	28092	37N	11E	2 (SE)	16 W 267 93RD (SE,NW,SE)	BILL ALLEN BLDRS.	2/22/83	180	OPEN	132-180	99	ROCK
165	28204	37N	11E	2 (SE)	2927 S. 48TH AVE.(NW,SW,SE)	BILL CARSTEN	6/16/88	200	OPEN	145-200	89	LIMESTONE
166		37N	11E	2 (SW)	10 S 731 JACKSON ST.(SE,NW,SW)	CHESTER GASAWAY	5/7/80	220	OPEN	160-220	130	LIMESTONE
167	63	37N	11E	2 (SW)	NW 1/4 OF NW 1/4 OF SW 1/4	RAMLIN ROSE SOUTH	7/18/67	1610	OPEN	512-1610	594	LS/SW/SS
168	907	37N	11E	2 (SW)	NW 1/4 OF NW 1/4 OF SW 1/4	RAMLIN ROSE SOUTH	1967	249	OPEN	108-249	78	LIMESTONE
169	2058	37N	11E	2 (SW)	NW 1/4 OF NE 1/4 OF SW 1/4	RAMBLIN ROSE	10/4/70	300	OPEN	120-300	77	LS/SW
170	2339	37N	11E	2 (SW)	16 W 301 94TH ST. (S/2,S/2)	ROBERT HABADA	1/3/72	220	OPEN	156-220	78	ROCK
171	25223	37N	11E	2 (SW)	9454 S. JACKSON	DENNIS ANDRYSIAK	9/14/78	180	OPEN	150-180	45	LIMESTONE
172		37N	11E	3 (NE)	16 W 451 HILLSIDE (SW,NW,NE)	HANS DEV. CO.	7/1/89	220	OPEN	140-220	100	LIMESTONE
173	503	37N	11E	3 (NE)	TIMBERLAKE ESTS. #94 (NE,NE,NE)	HENRY JOUKEMA	1959	191	OPEN	153-191	90	LIMESTONE
174	1567	37N	11E	3 (NE)	10 S. 140 LEONARD (SW,NW,NE)	IVAN PUMMEL	1966	150	OPEN	115-150	55	LIMESTONE
175	2088	37N	11E	3 (NE)	TIMBERLAKE ESTS. #38 (NE,NE,NE)	CHESTER GASAWAY	7/13/71	150	OPEN	130-150	40	ROCK
176	23803	37N	11E	3 (NE)	17 W 268 HILLSIDE (SW,NE,NE)	WILLIAM CALABRETTA	8/22/74	190	OPEN	136-190	75	LIMESTONE
177	25230	37N	11E	3 (NE)	4736 MAIN ST. (TLE #88)	KELLOG-BENET BLDG.	5/20/78	160	OPEN	147-160	78	LIMESTONE
178	27078	37N	11E	3 (NE)	17 W 155 W. 87TH ST. (NE,NE)	GEORGE SKUDRNA	6/24/85	200	OPEN	150-200	99	LIMESTONE
179	28002	37N	11E	3 (NE)	4741 CUMNOR RD. (NE,NE,NE)	JACK SPINNEY	10/26/87	200	STL CAS?	0-200	89	LIMESTONE
180	28429	37N	11E	3 (NE)	NE 1/4 OF NW 1/4 OF NE 1/4	DAVE KELLEY	12/4/84	245	OPEN	145-245	50	LIMESTONE
181	24320	37N	11E	3 (NW)	10 S 020 LORRAINE (N/2,NE,NW)	ACCURATE DESIGN	11/5/75	200	OPEN	148-200	90	LIMESTONE

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
182	25229	37N	11E	3 (NW)	16 W 424 HILLSIDE (SE,NE,NW)	NICK BATISTICH	10/20/77	220	OPEN	147-220	150	LIMESTONE
183	27543	37N	11E	3 (NW)	NW 1/4 OF NW 1/4 OF NW 1/4	DU PAGE CO.	10/20/86	325	OPEN	101-325		LS/SH
184		37N	11E	3 (SE)	87TH ST. S. OF HINSDALE (NW,SE)	MAXWELL HOWARD	1932	138	OPEN	126-138		ROCK
185	24381	37N	11E	3 (SE)	NW 1/4 OF NW 1/4 OF SE 1/4	DU PAGE CO. FOREST	4/28/76	150	OPEN	105-150		LIMESTONE
186		37N	11E	3 (SW)	87TH ST. S. OF HINSDALE (NE,SW)	LOUIS REDIEHS		103	OPEN	86-103		ROCK
187		37N	11E	3 (SW)	DU PAGE CO. (SE,SW)	ARNOLD REDISH	1924	91	OPEN	69-91		ROCK
188		37N	11E	3 (SW)	DU PAGE CO. (SE,SW)	MALIKOWSKI	1914	85	OPEN	63-85	13	ROCK
189		37N	11E	3 (SW)	DU PAGE CO. (NE,SW)	SMITH		100	OPEN	96-100		ROCK
190	654	37N	11E	3 (SW)	NE 1/4 OF SW 1/4 OF SW 1/4	ARGONNE LAB		110	OPEN?	80-110	37	LIMESTONE
191	1566	37N	11E	3 (SW)	SW 1/4 OF SW 1/4 OF SW 1/4	ARGONNE LAB	1950	1595	OPEN?	64-1595		LS/SH/SS
192		37N	11E	4 (NE)	ARGONNE LAUNCHER AREA (NE,NE)	U.S. ARMY	1955	230	OPEN	140-230		
193		37N	11E	4 (NE)	881 W ST CHARLES RD.(NE,SE,NE)	FOREST PRESERVE	11/15/78	150	OPEN	110-150	58	LIMESTONE
194	1568	37N	11E	4 (NE)	DOWNER'S GROVE TWP. (NW,NW,NE)	WELCH		115				ROCK
195	218	37N	11E	4 (SE)	NE 1/4 OF SW 1/4 OF SE 1/4	ARGONNE LAB	2/59	341	OPEN	115-341	84	SIL/ORD DOL
196	656	37N	11E	9 (NE)	SW 1/4 OF SE 1/4 OF NE 1/4	ARGONNE LAB		186	OPEN	86-186		LIMESTONE
197	1571	37N	11E	9 (NE)	NE 1/4 OF NW 1/4 OF NE 1/4	ARGONNE LAB	6/64	331	OPEN	110-331	88	LS/SH
198	1572	37N	11E	9 (NE)	NE 1/4 OF NW 1/4 OF NE 1/4	ARGONNE LAB	6/64	331	OPEN	108-331	85	LS/SH
199	658	37N	11E	9 (SE)	SW 1/4 OF NW 1/4 OF SE 1/4	ARGONNE LAB		141	OPEN	86-141	101	LIMESTONE
200	659	37N	11E	9 (SE)	NE 1/4 OF NE 1/4 OF SE 1/4	ARGONNE LAB	1940	240	OPEN?	95-240	60	LIMESTONE
201	660	37N	11E	9 (SE)	NE 1/4 OF SE 1/4 OF SE 1/4	ARGONNE LAB	1921	148	OPEN?	86-148	111	LIMESTONE
202	661	37N	11E	9 (SE)	NE 1/4 OF SE 1/4 OF SE 1/4	ARGONNE LAB	1934	111	OPEN?	91-111		LIMESTONE
203	662	37N	11E	10 (NW)	NW 1/4 OF SE 1/4 OF NW 1/4	ARGONNE LAB	1934	97	OPEN?	63-97	22	LIMESTONE
204	664	37N	11E	10 (NW)	SE 1/4 OF SE 1/4 OF NW 1/4	ARGONNE LAB		160	OPEN	160-168		LIMESTONE
205	665	37N	11E	10 (NW)	NW 1/4 OF SW 1/4 OF NW 1/4	ARGONNE LAB		168	OPEN?	160-168	52	LIMESTONE
206	1509	37N	11E	10 (NW)	SW 1/4 OF NE 1/4 OF NW 1/4	ARGONNE LAB	1948	300	OPEN	61-300	70	SIL/ORD LS/SH
207	1510	37N	11E	10 (NW)	NE 1/4 OF SE 1/4 OF NW 1/4	ARGONNE LAB	1948	284	OPEN	75-284	75	SIL/ORD LS
208	2395	37N	11E	10 (NW)	SW 1/4 OF SW 1/4 OF NW 1/4	ARGONNE LAB		202	OPEN?	140-202	69	LIMESTONE
209	26215	37N	11E	10 (SE)	12 W LAKE ST.(SE,NW,SE)	DU PAGE CO.	3/5/81	200	OPEN	77-200	59	ROCK/SH
210	26216	37N	11E	10 (SE)	12 W LAKE ST.(SE,NW,SE)	DU PAGE CO.	1/23/81	160	OPEN	70-160	59	ROCK
211	663	37N	11E	10 (SW)	NW 1/4 OF SE 1/4 OF SW 1/4	ARGONNE LAB		95	OPEN?	50-95	72	LIMESTONE
212	714	37N	11E	10 (SW)	SW 1/4 OF SW 1/4 OF SW 1/4	ARGONNE LAB	1949	155	OPEN	115-155	107	LIMESTONE
213	510	37N	11E	11 (NE)	ASSESSMENT DIV. (SW,SW,NE)	ALLAN BECKMAN	1959	155	OPEN	105-155	80	LIMESTONE
214	1262	37N	11E	11 (NE)	11519 ROSEMER (NE,NE,NE)	EDWARD OTTO	11/29/69	180	OPEN	100-180	115	LIMESTONE
215	1276	37N	11E	11 (NE)	16 W 220 97TH (SE,NW,NE)	CARL PETERSON	9/10/69	150	OPEN	115-150	90	LIMESTONE

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
216	2268	37N	11E	11 (NE)	ASSESSMENT DIV. LOT #47 (SE,NE)	TONY ADRECUS	10/13/71	180	OPEN	142-180	78	ROCK
217	2981	37N	11E	11 (NE)	ASSESSMENT LOT #38 (SE,NW,NE)	RICHARD FLACS	9/27/72	180	OPEN	96-180	60	ROCK
218	3319	37N	11E	11 (NE)	SPRING ACRES #2 (LOT #5)	ARAZAN BLDRS.	7/30/73	190	OPEN	137-190	40	ROCK
219	3320	37N	11E	11 (NE)	SPRING ACRES LOT #4	JOHN HUSEK	7/30/73	185	OPEN	137-185	80	ROCK
220	23620	37N	11E	11 (NE)	11 S 058 PALISADES (N/2,NE)	C. SROKA	12/10/73	180	OPEN	140-180	129	ROCK
221	23696	37N	11E	11 (NE)	11 S 060 MADISON (NE,NE,NE)	RELIABLE CONST.	4/3/74	140	OPEN	66-140	50	LIMESTONE
222	23828	37N	11E	11 (NE)	11 S 204 MADISON (NE,NE)	JOHN MANGAN	7/31/74	100	OPEN	84-100	63	LIMESTONE
223	23997	37N	11E	11 (NE)	11 S 375 JEANS RD. (LOT #41)	RICHARD FLACS	12/13/74	100	OPEN	40-100	33	LIMESTONE
224	23998	37N	11E	11 (NE)	EDW. SASS ASSESS. (NE,NE,NE)	NICK MICHAELS	12/19/74	145	OPEN	84-145	58	LIMESTONE
225	24232	37N	11E	11 (NE)	10 S 571 MADISON (ES #34)	NICK MICHAELS	9/24/75	150	OPEN	105-150	60	LIMESTONE
226	25096	37N	11E	11 (NE)	ASSESSMENT DIV. (LOT #41)	TRISKA & FLACS	5/31/77	100	OPEN	40-100	8	LIMESTONE
227	25239	37N	11E	11 (NE)	16 W 235 97TH (NE,SW,NE)	CHESTER GASAWAY	10/18/77	130	OPEN	80-130	5	LIMESTONE
228	26217	37N	11E	11 (NE)	9700 S. MADISON (SE,SE,NE)	JOHN COURTNEY	10/9/79	145	OPEN	42-145	7	LIMESTONE
229	26219	37N	11E	11 (NE)	1138 TIMBER LANE (JEANS RD SUB)	EARL MAIER	11/12/80	110	OPEN	40-110	5	LIMESTONE
230	26220	37N	11E	11 (NE)	11 S 010 JACKSON ST. (NW,NW,NE)	EMILIE RANNIN	9/24/81	185	OPEN	140-185	119	LIMESTONE
231	26356	37N	11E	11 (NE)	SPRING ACRES LOT #6 (NW,NE)	DON SCHULTZ	9/11/84	185	OPEN	132-185	99	LIMESTONE
232	944	37N	11E	11 (SE)	DU PAGE CO.? (NE,NW,SE)	THOMAS REDIEHS	1967	100	OPEN	43-100	20	LIMESTONE
233	27164	37N	11E	11 (SE)	JEANS RD? (SE,NW,SE)	CORWIN LENZ	9/13/85	125	OPEN	42-125	14	LIMESTONE
234	1275	37N	11E	11 (SW)	16 W 515 99TH ST. (SE,NE,SW)	NICK BATISTICH	11/13/69	165	OPEN	133-165	105	LIMESTONE
235	26218	37N	11E	11 (SW)	NW 1/4 OF NW 1/4 OF SW 1/4	DU PAGE CO.	1/14/83	200	OPEN	75-200	39	ROCK
236	2949	37N	11E	12 (NW)	SPACE VALLEY SUB. (LOT #13)	SEFARA BLDRS.	7/13/72	180	OPEN	132-180	60	ROCK
237	23804	37N	11E	12 (NW)	11 S 165 MADISON (NW,NW,NW)	JIM ADCOCK	8/22/74	120	OPEN	52-120	8	LIMESTONE
238	25097	37N	11E	12 (NW)	8101 COUNTY LINE RD. (W/2,NW)	GEORGE REDIEHS	4/15/77	125	OPEN	40-125	4	LIMESTONE
239	26221	37N	11E	12 (SW)	TREATMENT PLANT (NW,NW,SW)	DU PAGE CO.	11/21/83	145	OPEN	32-145	5	LIMESTONE
240	28430	37N	11E	12 (SW)	15700 S. LaGRANGE RD. (NW,NW,SW)	KERR TRAILER	1/9/85	150	OPEN	40-150	4	ROCK
241		37N	11E	13 (NW)		MURPHY	1947	75	OPEN?	31-75		ROCK
242		37N	11E	13 (NW)		TOM MURPHY		79	OPEN?	31-79		ROCK
243		37N	11E	13 (NW)		TOM MURPHY		92	OPEN?	55-92		ROCK
244		37N	11E	13 (SW)		GEORGE RENBONE		40	OPEN?	5-40		ROCK
245		37N	11E	13 (SW)	SAG BRIDGE	AMY KIRK		68	OPEN?	13-68		ROCK
246		37N	11E	13 (SW)		SAG SCHOOL	1915	69	OPEN	20-69		ROCK
247		37N	11E	14 (NE)	117TH & ARCHER (NW,SE,NE)	HILDA KIRK	7/28/71	70	OPEN	40-70	44	LS/SH
248		37N	11E	14 (NE)	LEMONT TWP.	HEYWORTH	1915	35	OPEN	27-35		ROCK
249		37N	11E	14 (NE?)	CONST. CAMP FOR CANAL	HEYWORTH	1915	49	OPEN	27-49		ROCK
250		37N	11E	14 (NW)		M. POLAREK	1926	58	OPEN	26-58		ROCK

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN-SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
251	10 - 16	37N	11E	14 (NW)	CAL-SAG CHANNEL:7 SITES (S/2,NW)	CORPS OF ENGRS.	<10/1/46	22-26	BORINGS			LIMESTONE
252		37N	11E	14 (S/2)	CHICAGO-JOLIET RD.(S/2,S/2)	AL ALBRECHT	3/10/75	120	OPEN	63-120	50	LIMESTONE
253		37N	11E	14 (SE)	111TH & ARCHER	MRS. RUPERT	1913	60	OPEN	22-60		ROCK
254	28597	37N	11E	15 (NE)	5925 BENTLEY (NE,SE,NE)	JAMES TILLEY	8/21/84	240	OPEN	132-240	129	ROCK
255		37N	11E	15 (SE)	JOESEPH N. PEW'S SUBD. (LOT #3)	JIM ADCOCK	12/20/78	105	OPEN	40-105	3	LIMESTONE
256	26981	37N	11E	15 (SE)	LEMONT HIGHWAY RD. (SE,SE,SE)	JOHN DEYOUNG	8/22/85	145	OPEN	40-145	19	LIMESTONE
257	786-792	37N	11E	15 (SE?)	DU PAGE CO.? - 7 SITES	N. IL GAS CO.	10/62	28-90	BORINGS?			LIMESTONE
258		37N	11E	15 (SW)	BURR RIDGE (NW,SW,SW)	GENE VINEYARD	3/20/81	105	OPEN	42-105	9	LIMESTONE
259	1457	37N	11E	16 (SE)	SW 1/4 OF SW 1/4 OF SE 1/4	RICHMOND BUILDERS	12/13/70	160	OPEN	127-160	18	ROCK
260		37N	11E	22 (NE)		JOHN MCGRAW	1916	100	OPEN	65-100		ROCK
261		37N	11E	22 (NE)	1598 MAIN ST. (SE,NW,NE)	COUNTRY CLUB	5/17/77	151	OPEN	77-151	65	LIMESTONE
262	27102	37N	11E	22 (NW)	NW 1/4 OF NW 1/4 OF NW 1/4	PATRICIA STRADER	8/5/85	100	OPEN	40-100	19	ROCK
263	29293	37N	11E	22 (NW)	1134 KOTLEN (NW,NW)	RONALD BUSHMAN	9/18/84	180	OPEN	40-180	39	ROCK
264	29294	37N	11E	22 (NW)	114TH ST & WALKER RD.(SW,SW,NW)	NEIL LINDBERG	10/17/79	180	OPEN	50-180	19	ROCK
265	29296	37N	11E	22 (NW)	1349 MAGIN ST. (NW,SW,NW)	EMITY McCUTCHEON	9/17/81	225	OPEN	42-225	39	LS/SH
266		37N	11E	23 (NE)	LEMONT TWP.	P.J. RUPERT	1907	200	OPEN	77-200	>75	ROCK
267		37N	11E	23 (NE)	LEMONT TWP.(NE,NE)	CONWAY	11/3/47	200				
268		37N	11E	23 (NE)	16 ARTESIAN-AG #16 (E/2, NE)	NICK BATISTICH	11/16/72	140	OPEN	88-140	79	ROCK
269	766	37N	11E	23 (NE)	ARCHER & BELL (E/2, NE)	E. BELGRAVE	10/8/68	115	OPEN	81-115	59	ROCK
270	1374	37N	11E	23 (NE)	AG LOT #28 (SW,SE,NE)	RAY RUDIS BLDRS.	9/6/71	150	OPEN	85-150	59	ROCK
271	1523	37N	11E	23 (NE)	RTE. 1 WOODLANE AVE.(SW,SW,NE)	KETTELL CONST.	3/24/72	135	OPEN	85-135	74	LIMESTONE
272	1644	37N	11E	23 (NE)	CAMPBELL ST LOT #30 (NE,SE,NE)	JAMES DEMPSEY	11/17/71	160	OPEN	84-160	59	ROCK
273	4416	37N	11E	23 (NE)	ARCHER GARDENS LOT #51	CHESTER GASAWAY	8/3/73	120	OPEN	80-120	40	ROCK
274	25384	37N	11E	23 (NE)	BELL & CAMPBELL RDS.(NE,SE,NE)	ALLEN HULL BLDRS.	6/7/76	100	OPEN	70-100	49	ROCK
275	25812	37N	11E	23 (NE)	AG LOT #50 (E/2, NE)	ROBERT KOLOOMNSKI	7/28/77	215	OPEN	82-215	59	ROCK
276	26306	37N	11E	23 (NE)	ARCHER GARDENS LOT #2(NW,SE,NE)	FRANK PICK	9/19/77	185	OPEN	90-185	82	LIMESTONE
277		37N	11E	23 (NE?)	ARCHER GARDENS LOT #38	WOHEAD BLDRS.	6/27/73	130	OPEN	70-130	55	LIMESTONE
278		37N	11E	23 (NW)	113TH PL. & BELL RD.(E/2,NW)	K.V. BLDRS.	11/2/74	170	OPEN	100-170	64	ROCK
279	2087	37N	11E	23 (NW)	SE 1/4 OF SE 1/4 OF NW 1/4	COUNTRY CLUB	7/63	297	OPEN	87-297	52	LS/SH
280	2088	37N	11E	23 (NW)	SW 1/4 OF SW 1/4 OF NW 1/4	COUNTRY CLUB	10/20/66	300	OPEN	60-200	43	LS/SH
281		37N	11E	23 (SW)	LEMONT TWP.	JOHN DOMINICK	1915	150	OPEN	115-150	50	ROCK
282	585	37N	11E	23 (SW)	SE 1/4 OF NW 1/4 OF SW 1/4	COUNTRY CLUB	10/20/67	335	OPEN	112-335	73	LIMESTONE
283	29297	37N	11E	23 (SE)	BELL RD. (SE,NE,SE)	JOE KEIM BLDRS.	1/10/80					

TABLE 4-9
LENZ OIL SITE
PRIVATE WELL DATA

ERM NO.	COUNTY NO.	TOWN- SHIP	RANGE	SEC(1/4)	LOCATION	OWNER	DATE COMPLETED	TOTAL DEPTH	SCREEN MATL.	SCREENED INTERVAL	STATIC WATER	GEOLOGIC MATERIAL
284	2089	37N	11E	24 (N/2)	RTE. 83 E. SAG BRIDGE (N/2,N/2)	CCC CAMP AT LEMONT	1944	160	OPEN	53-160	35	LIMESTONE
285		37N	11E	24 (NW)	LEMONT TWP. (SW,NW)	PETE MICHEK	1913	135	OPEN	89-135		ROCK
286		37N	11E	24 (NW)	LEMONT TWP. (NE,NW)	L. MATHY	1927	130	OPEN	50-130	25	ROCK
287		37N	11E	24 (NW)	LEMONT TWP. (NW,NW)	JOHN JALINSKI	1915	33	OPEN	30-33		BKN LIME
288		37N	11E	24 (NW)	59 RUSTY RD.(SW,SE,NW)	BILL RIORDAN	9/9/88	205	OPEN	79-205	69	LIMESTONE
289		37N	11E	24 (NW)	EQUEST. ESTS. LOT #94	BIG M BLDRS.	12/3/79	155	OPEN	63-155	49	ROCK
290	25386	37N	11E	24 (NW)	DINEFF & PISHONS (NW,NW,NW)	NICK BATISTICH	10/13/76	180	OPEN	52-180	43	LIMESTONE
291	25814	37N	11E	24 (NW)	115TH & DINEFF (S/2,SW,NW)	DAN BENIGNE	5/26/78	160	OPEN	73-160	100	LIMESTONE
292	26117	37N	11E	24 (NW)	RTE 83 & ARCHER & 111TH (NW,NW)	KORZENECHI & CO.	10/17/78	155	OPEN	42-155	29	LIMESTONE
293	26309	37N	11E	24 (NW)	BELL RD. & RTE. 171 (NW,NW,NW)	JOE ROGOWSKI	5/5/78	185	OPEN	55-185	44	LIMESTONE
294	27132	37N	11E	24 (NW)	EE LOT #139	OVERSTREET BLDRS.	9/16/85	160	OPEN	130-160	89	LIMESTONE
295	27193	37N	11E	24 (NW)	113TH & DINEFF (SW,SW,NW)	FRANK HART	2/19/86	205	OPEN	63-205	54	LS/SH
296	27215	37N	11E	24 (NW)	EQUESTRIAN LOT #151 (NE,NW,NW)	DENNIS IRELAND	12/4/85	185	OPEN	98-185	49	LIMESTONE
297	27473	37N	11E	24 (NW)	115TH DINEFF (SW,SW,NW)	SCOTT OLDANI	7/9/87	200	OPEN	63-200	44	LIMESTONE
298	27504	37N	11E	24 (NW)	EQUEST. ESTS.#97 (SE,NW,NW)	JOHN FARANO	7/10/87	205	OPEN	60-205	29	LIMESTONE
299	28203	37N	11E	24 (NW)	EE LOT #13 (SW,SE,NW)	KEN LARIMER	10/15/87	205	OPEN	91-205	49	LIMESTONE
300	28232	37N	11E	24 (NW)	7560 BLAZER AVE.(NW,NW,NW)	FRED FIERKE	7/14/88	200	OPEN	60-200	79	ROCK
301	28608	37N	11E	24 (NW)	17239 OAK PARK (NW,NW,NW)	STARK CONST.	11/28/88	300	OPEN	146-300	79	ROCK
302	28678	37N	11E	24 (NW)	1052 REPUBLIC DR.(SW,SW,NW)	MARK WILSON	6/17/88	220	OPEN	101-220	42	LIMESTONE
303	29819	37N	11E	24 (NW)	EE LOT #95 (NW,SE,NW)	B & K DEVL.	5/8/80	220	OPEN	65-220	59	ROCK
304		37N	11E	24 (SW)	EE LOT #64 (NW,NW,SW)	MIKE WITT	2/15/80	185	OPEN	132-180	69	ROCK
305		37N	11E	24 (SW)	EE LOT #8 (NW,NW,SW)	DONNA KRAMER	4/5/79	200	OPEN	101-200	49	LIMESTONE
306	2090	37N	11E	24 (SW)	LEMONT TWP. (NW,NE,SW)	MIKE FLYNN	1939	260	OPEN?	100-260	45	ROCK
307	25816	37N	11E	24 (SW)	EE LOT #28 (NW,NW,SW)	CULTRA CONST.	7/13/78	185	OPEN	118-185	89	LIMESTONE
308	29303	37N	11E	24 (SW)	EE LOT #8 (NW,NW,SW)	DONNA KRAMER	4/4/79	200	OPEN	105-200	74	LIMESTONE
309	29311	37N	11E	24 (SW)	EE LOT #26 (NW,NW,SW)	CARL RUMER	1/9/80	140	OPEN	116-140	74	ROCK
310	29313	37N	11E	24 (SW)	16210 OAK VALLEY TR.(NE,NW,SW)	LATEERA BLDRS.	6/15/69	165	OPEN	126-165	89	LIMESTONE

SAG BRIDGE QUADRANGLE

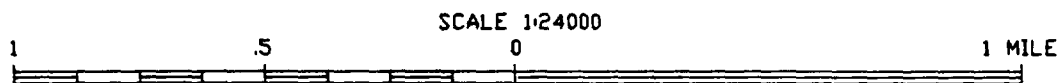
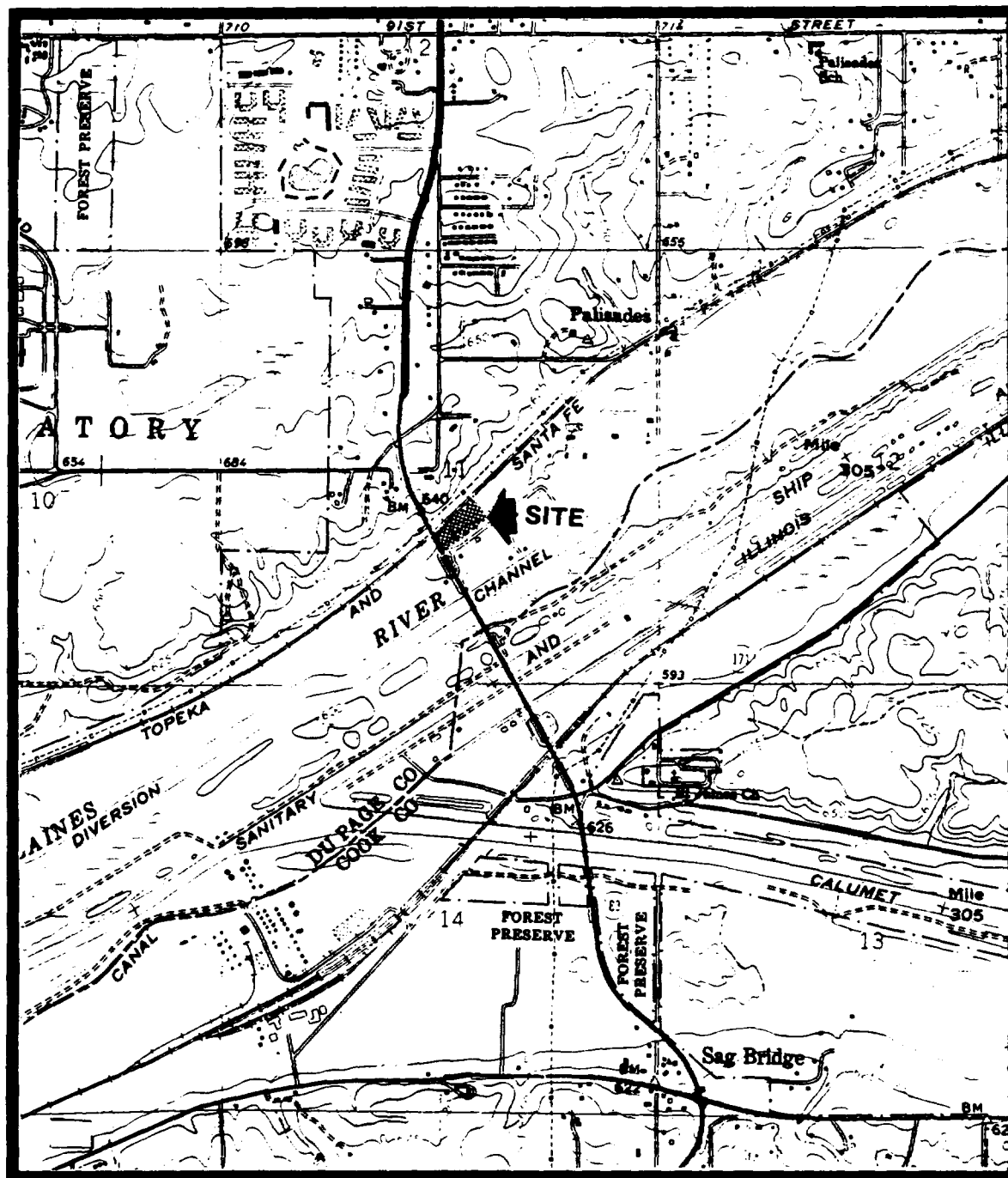
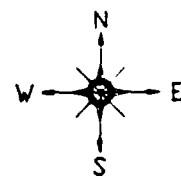
ILLINOIS

7.5 MINUTE SERIES (TOPOGRAPHIC)

1963

PHOTOREVISED 1973

PHOTOINSPECTED 1978



CONTOUR INTERVAL 5 FEET

FIGURE 2-1

SITE LOCATION MAP
LENZ OIL SITE



ERM

PROJECT: 0252
REPORT: TMJ
DRAWN: BLAS
CHECKED:
DATE: 5/1/91
APPROVED:
CLIENT NAME: LENZ OIL

SDMS US EPA REGION V

FORMAT- OVERSIZED - 5


IMAGERY INSERT FORM

The item(s) listed below are not available in SDMS. In order to view original document or document pages, contact the Superfund Records Center.

SITE NAME	LENZ OIL		
DOC ID #	161202		
DESCRIPTION OF ITEM(S)	FIGURE 2-2		
REASON WHY UNSCANNABLE	<u> X </u> OVERSIZED	OR	<u> </u> FORMAT
DATE OF ITEM(S)	10/16/92		
NO. OF ITEM	1		
PHASE	REM		
PRP	RMD		
PHASE (AR DOCUMENTS ONLY)	<u> </u> Remedial <u> </u> Removal <u> </u> Deletion Docket <u> </u> AR <u> </u> Original <u> </u> Update # <u> </u> Volume <u> </u> of <u> </u>		
COMMENT(S)			

THE LENZ OIL SITE IS LOCATED ON THE EAST SIDE OF JEANS ROAD. SAID BENCHMARK IS A 10" D.I. BENCHMARK ON AN INLET DRAINAGE STRUCTURE IN THE MEDIAN OF ILLINOIS ROUTE 83 LOCATED JUST SOUTH OF 97TH STREET EXTENDED WEST, PUBLISHED ELEVATIONS: 665.42).

2. TOPOGRAPHY PREPARED BY PATRICK ENGINEERING INC. IN JANUARY 1991.
3. THE SITE GRID SYSTEM CONTROL POINTS ARE AN IRON ROD LOCATED NEAR THE EAST CORNER OF THE SOUTH ABUTMENT OF THE ILLINOIS ROUTE 83 BRIDGE WITH SITE COORDINATES 4+50 NORTH AND 0+00 EAST AND A PK NAIL LOCATED APPROXIMATELY 3 FEET NORTH OF THE SOUTH EDGE OF PAVEMENT OF JEANS ROAD WITH SITE COORDINATES 4+50 NORTH AND 7+00 EAST.
4. GROUND ELEVATIONS HAVE BEEN ROUNDED TO THE NEAREST 0.1 FEET.
5. UNDERGROUND UTILITIES WERE LOCATED ON THE LENZ OIL SITE BY THE UTILITY OWNERS. ONLY THE ABOVE GROUND FEATURE ASSOCIATED WITH UNDERGROUND UTILITIES WERE LOCATED IN AREAS OFF THE LENZ OIL SITE. ANYONE PLANNING TO MAKE EXCAVATIONS ON THE LENZ OIL SITE OR SURROUNDING AREA SHOULD CONTACT J.U.L.I.E. (1-800-892-0123) AT LEAST TWO WORKING DAYS BEFORE STARTING ANY EXCAVATIONS.

APPROX SCALE (H.)

 NOT DRAWN TO SCALE







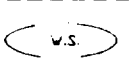









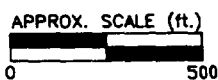
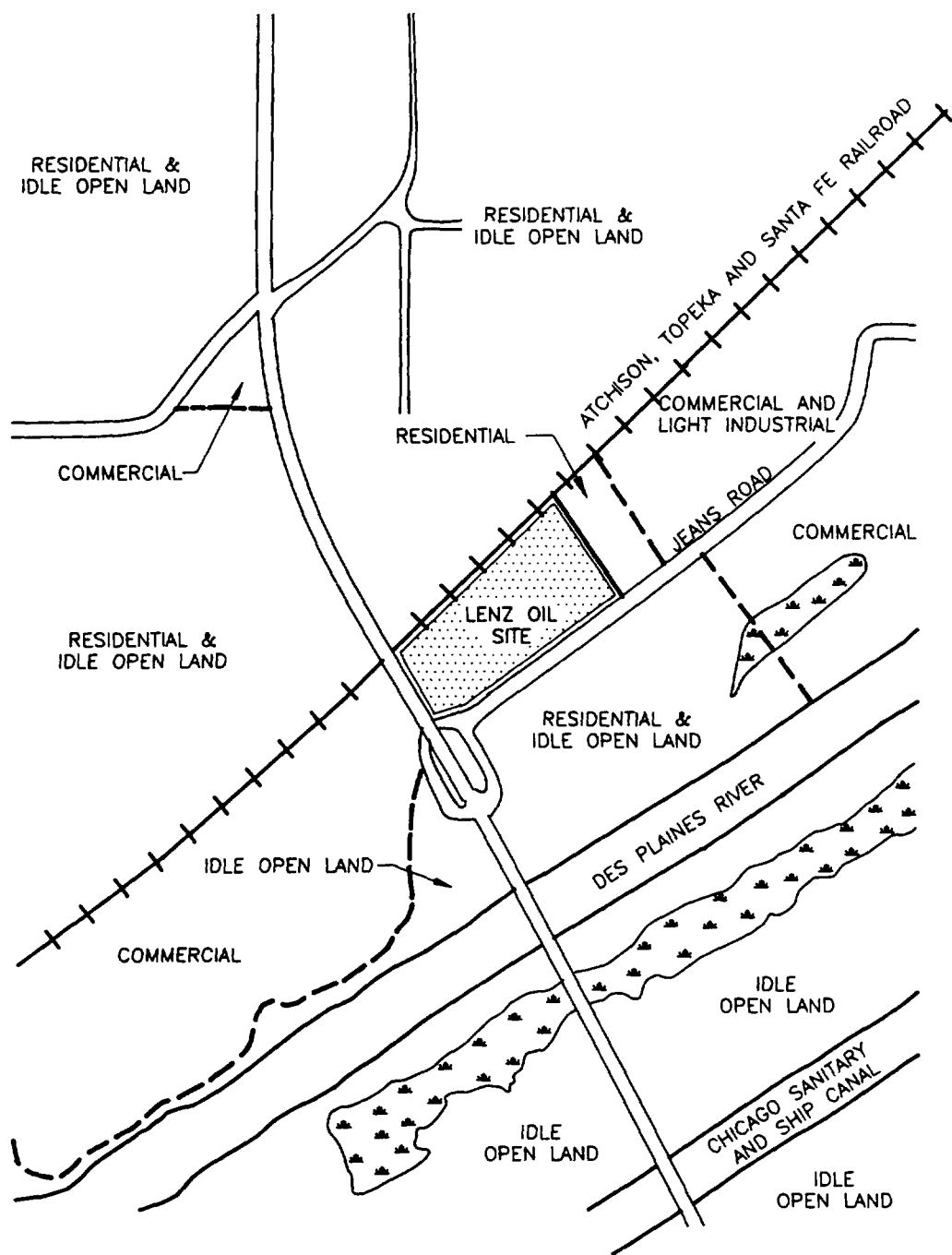
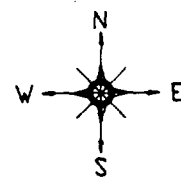
SYMBOL LEGEND:	
	PROPERTY LINE
	FENCE LINE
	GUARD RAIL
	RAILROAD
	WATER MAIN
	APPROX. PIPELINE LOC.
	WATER SURFACE
	EDGE OF WATER
	MONITORING WELL
	FIRE HYDRANT
	POWER POLE
	STOP SIGN
	BOLLARD
	PIPELINE MONUMENT
	IL. BELL TELEPHONE BOX
	BUILDING

FIGURE 2-2

**BASE MAP
LENZ OIL SITE**



SYMBOL LEGEND:	
	LAND USE BOUNDARY
	WET LANDS

FIGURE 2-3
LAND USE MAP
LENZ OIL SITE

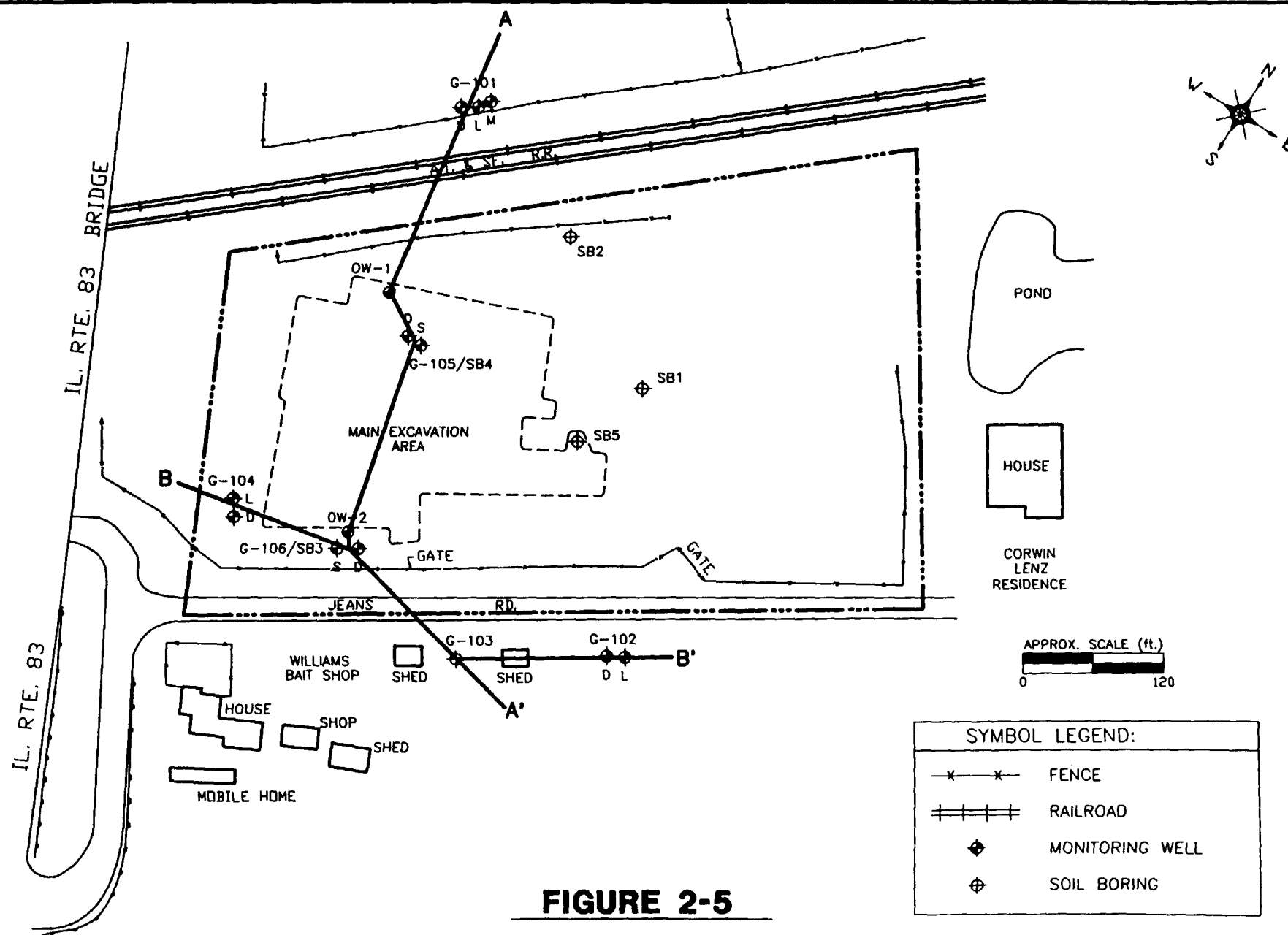
GEOLOGY OF THE CHICAGO AREA

Time Strating	Rock Strati	Stratigraphy	GRAPHIC COLUMN	Thickness (feet)	KINDS OF ROCK
SYSTEM	SERIES	STAGE	MEGA-GROUP	GROUP	FORMATION
QUAT.	PLEIS.				(See fig 15)
PENN.	DESM.				Keweenaw
MISS.	VAL.				Carbonate
DEV.	KIND.				Spoon
					Burl-Kaskaskia
					Hennipaw
					Grassy Creek
					Rocine
					Waukena
					Joliet
					Kankakee
					Edgewood
					Madison
					Blount
					Fl. Atkinson
					Scales
					Wise Lane
					Dunleith
					Guttenberg
					McGusta
					Grand Detour
					Mifflin
					Pecatonica
					Glenwood
					St. Peter
					Shakopee
					New Richmond
					Oreolo
					Gunter
					Eminence
					Peterson
					Francisco
					Ironston
					Galesville
					Eau Claire
					Mt. Simon
					Granite

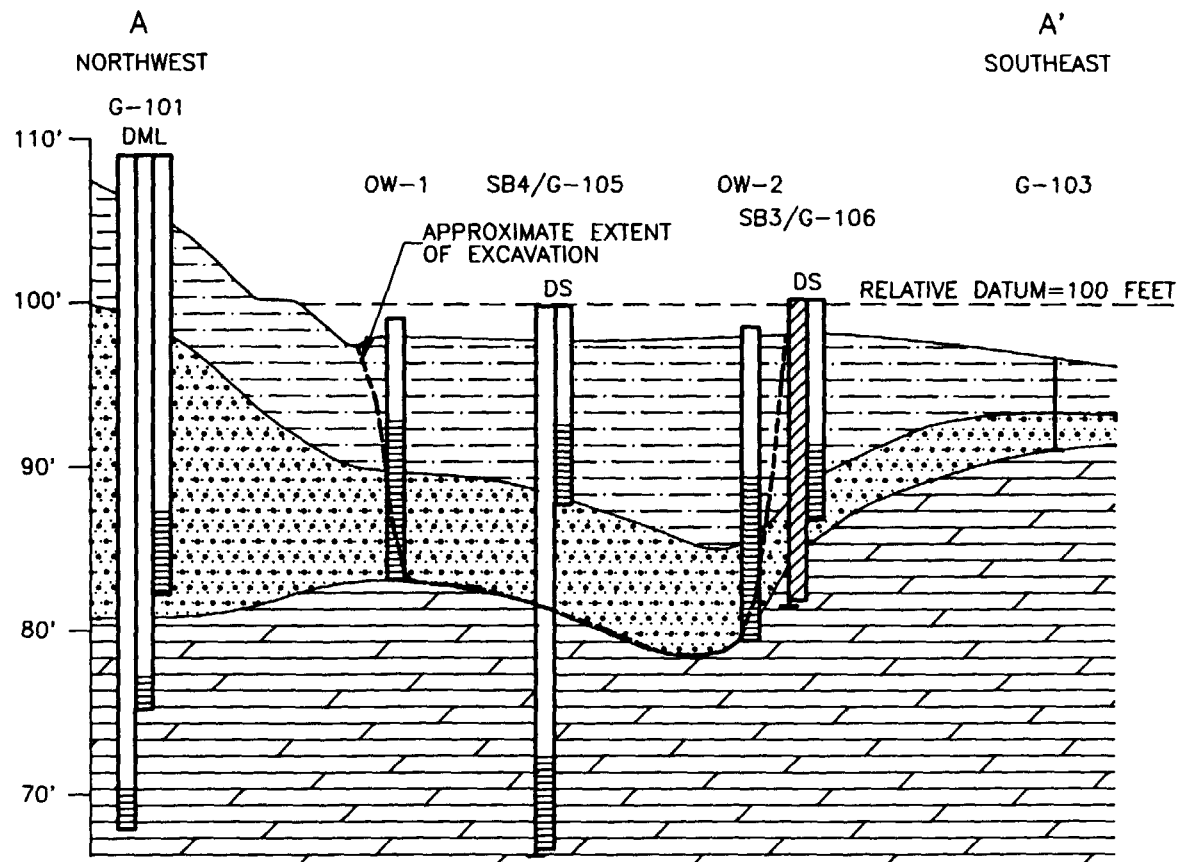
FIGURE 2-4

GENERALIZED STRATIGRAPHIC COLUMN FOR THE CHICAGO AREA FROM WILLMAN, 1971

PROJECT	REPORT	DRAWN	CHECKED	DATE	APPROVED	CLIENT NAME
0252	TM1	GW		2/4/01		LENZ OIL



PROJECT:	REPORT:	DRAWN:	CHECKED:	DATE:	APPROVED:
0252	TM1	MO		2/4/91	



APPROX. SCALE (ft.)

0 100

SYMBOL LEGEND:




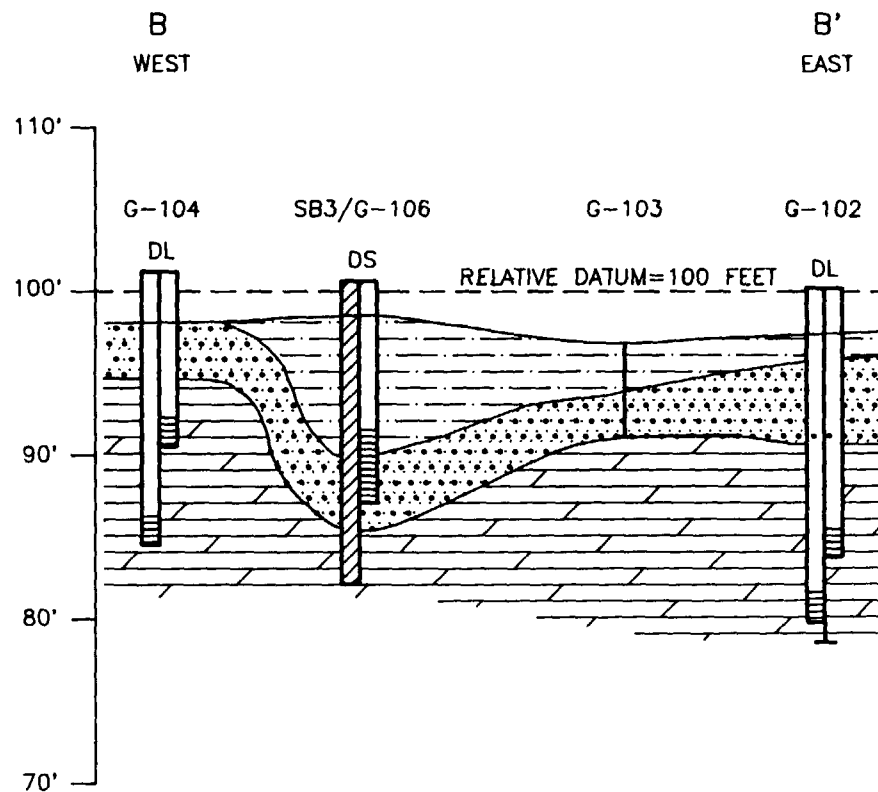
-  SILT, CLAYEY SILT AND SILTY SAND
-  WEATHERED DOLOMITE
-  RACINE FORMATION (DOLOMITE)

FIGURE 2-6
STRATIGRAPHIC CROSS SECTION A-A'
LENZ OIL SITE



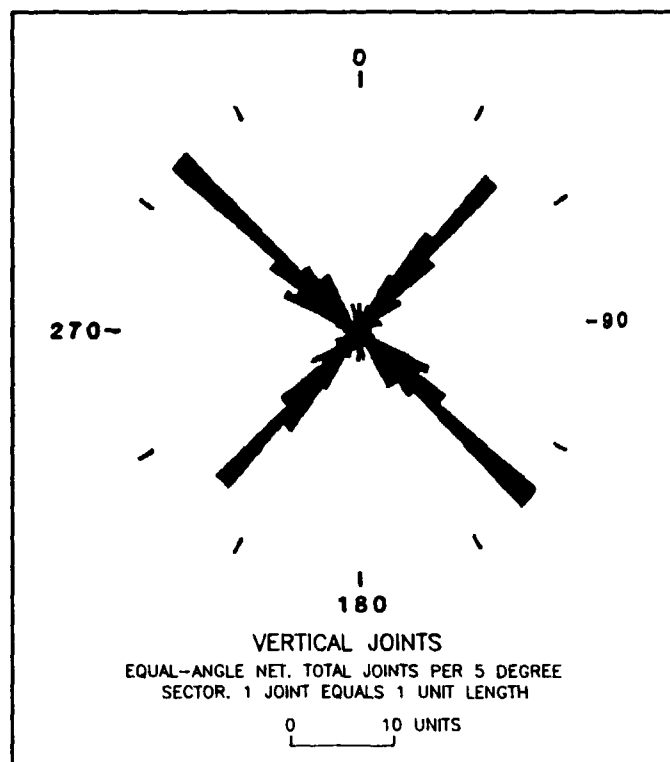
APPROX. SCALE (ft.)

SYMBOL LEGEND:

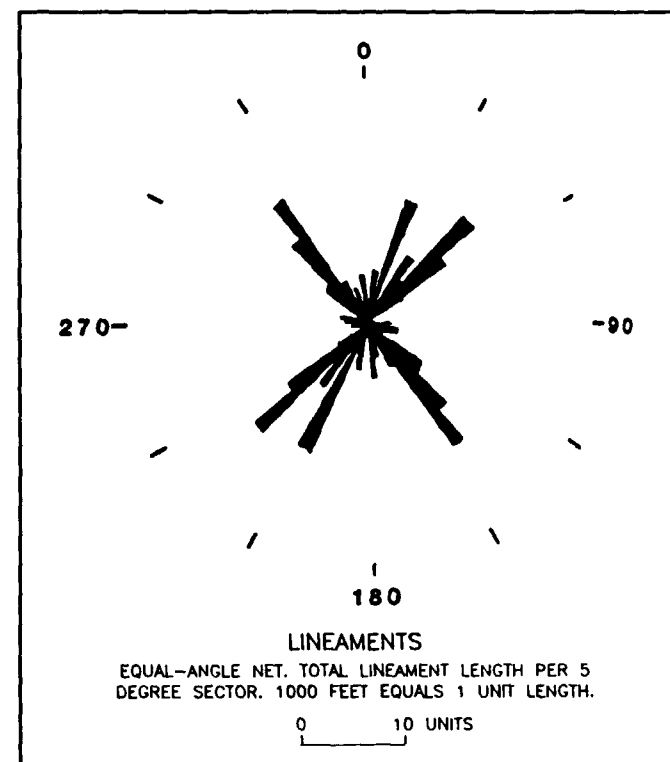
- | | |
|--|-------------------------------------|
| | SILT, CLAYEY SILT
AND SILTY SAND |
| | WEATHERED DOLOMITE |
| | RACINE FORMATION
(DOLOMITE) |

FIGURE 2-7
STRATIGRAPHIC CROSS SECTION B-B'
LENZ OIL SITE

PROJECT	REPORT	DRAWN	CHECKED	DATE	APPROVED
0252	TM1	MO		4/29/91	



A



B

NOTE: ORIENTATIONS ARE IN DEGREES AZIMUTH;
ZERO DEGREES IS TRUE NORTH. MODIFIED
FROM NICHOLAS AND HEALY (1988).

FIGURE 2-8

U.S.G.S.
VERTICAL JOINT AND LINEAMENT
ORIENTATION DATA
LEMONT, ILLINOIS AREA

SAG BRIDGE QUADRANGLE
ILLINOIS
7.5 MINUTE SERIES (TOPOGRAPHIC)
1963
PHOTOREVISED 1973
PHOTOINSPECTED 1978

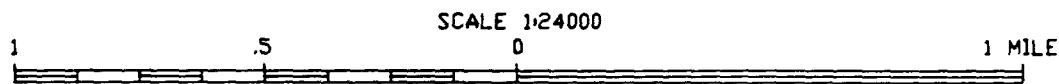
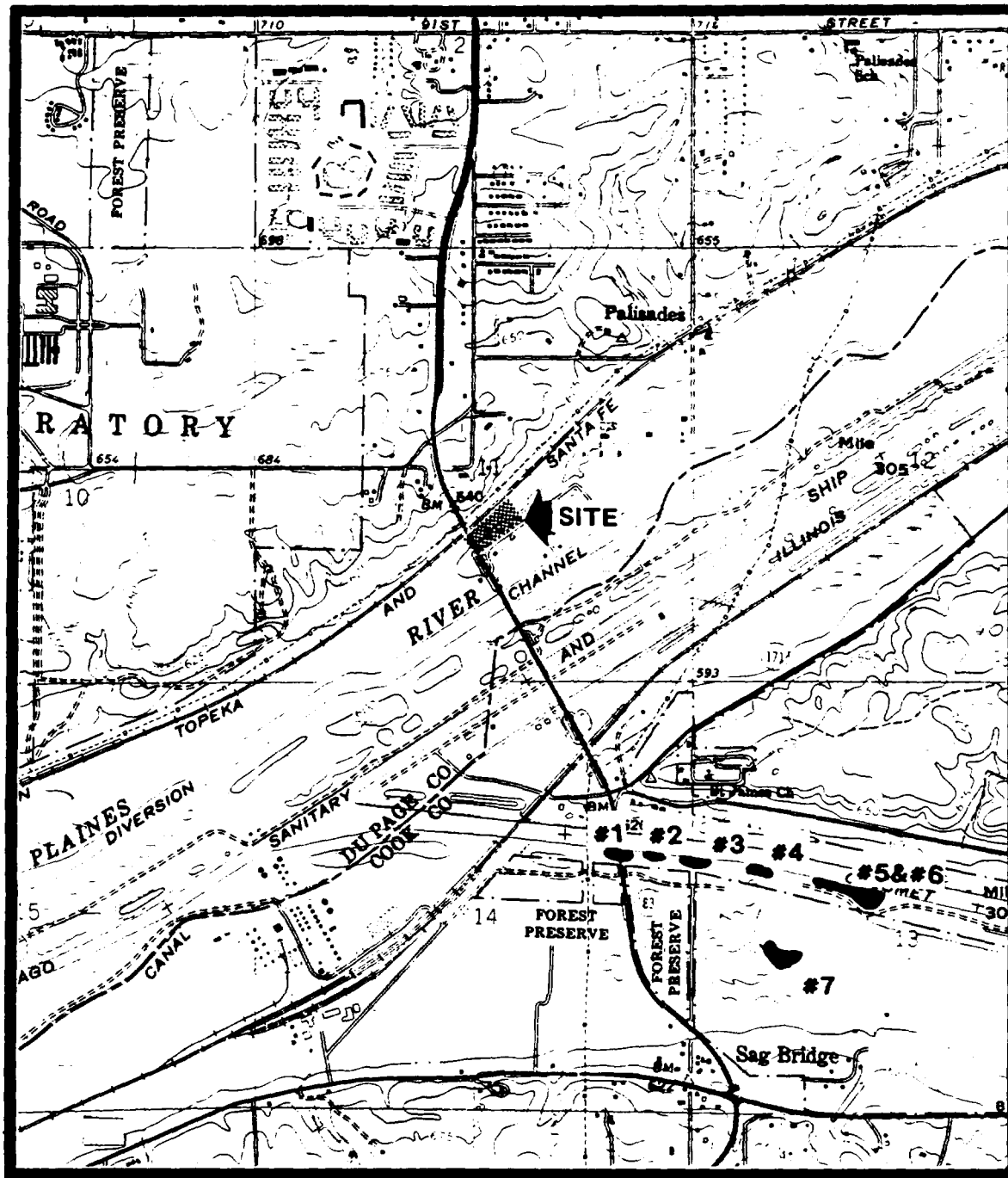
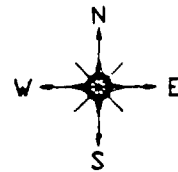


FIGURE 2-9

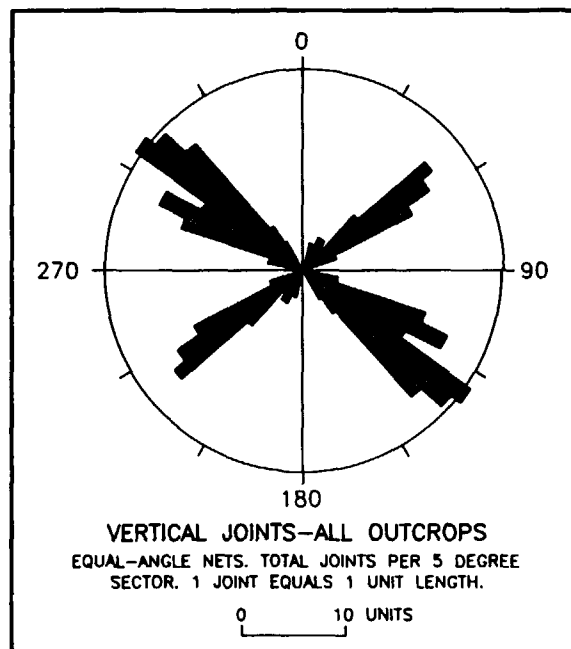
OUTCROP LOCATION MAP
LENZ OIL SITE

SYMBOL LEGEND:

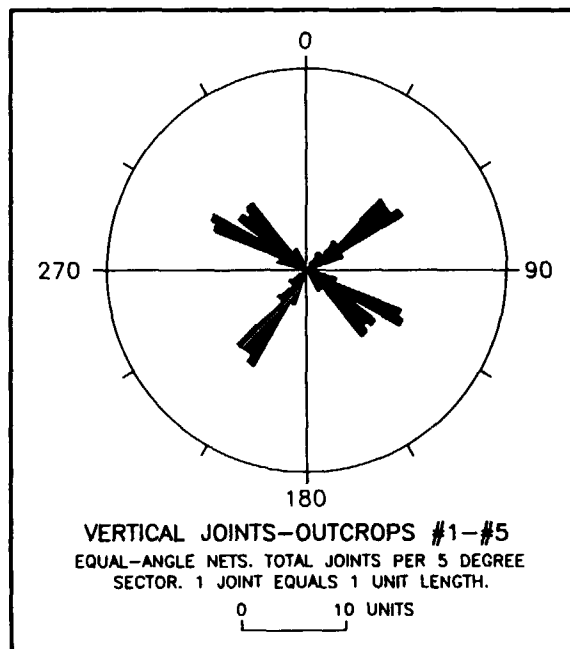
OUTCROP USED FOR
JOINT MEASUREMENTS

ERM

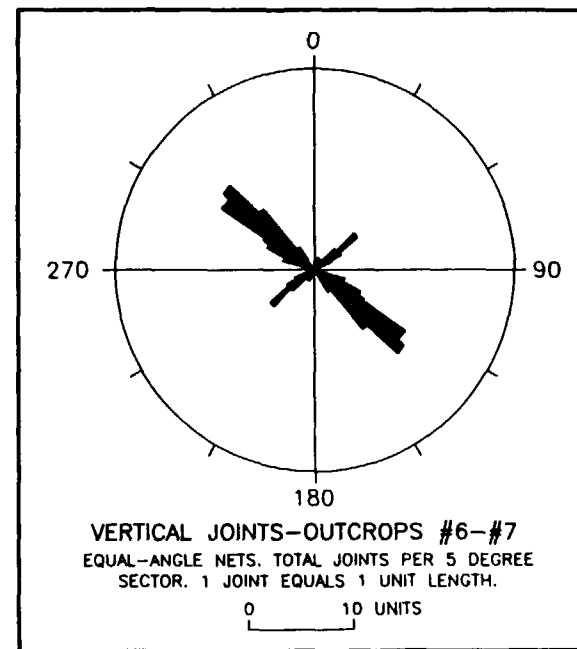
PROJECT: 0252
APP: TM1
BLAS
CHECKED
DATE: 5/1/91
APPROVED
CLIENT: LENZ OIL



A



B

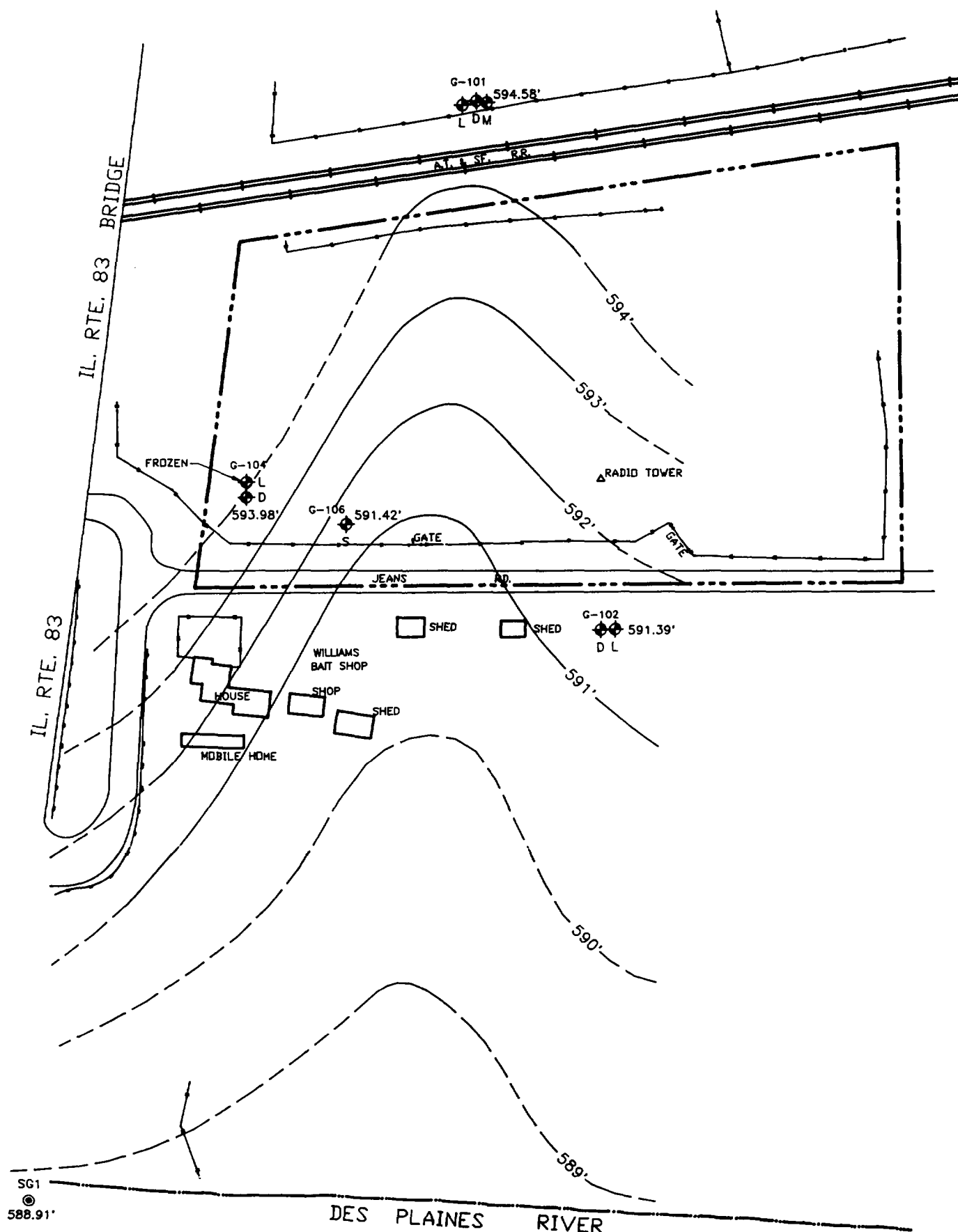


C

NOTE: ORIENTATIONS ARE IN DEGREES AZIMUTH.
ZERO DEGREES IS TRUE NORTH.

FIGURE 2-10

**ERM VERTICAL JOINT
ORIENTATION DATA
LEMONT, ILLINOIS AREA**



APPROX. SCALE (ft.)

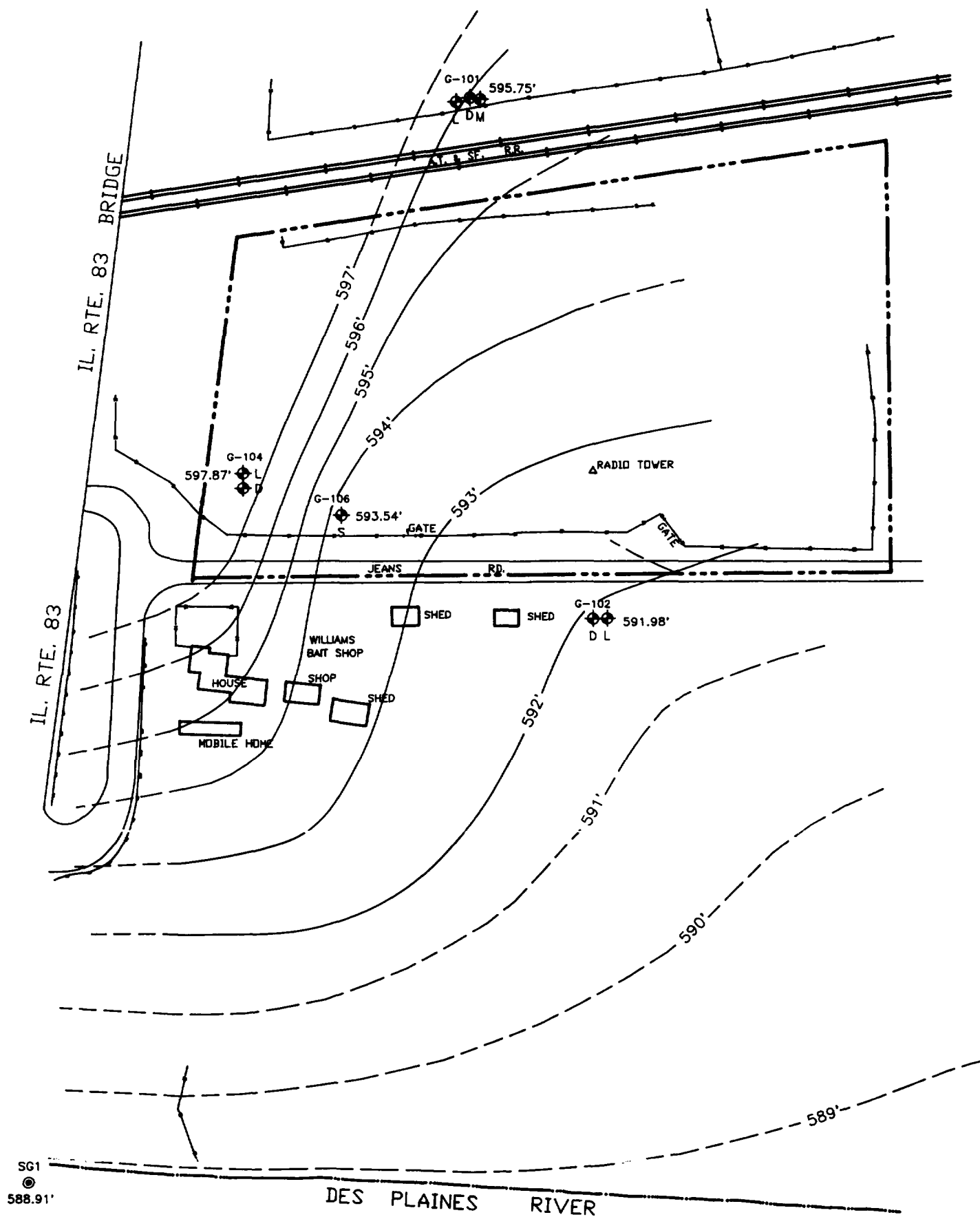
0 120

NOTE:
SOUNDING OF WELLS ON 1/29/91
INDICATED THAT WELLS G-101M, G-102L
G-104L, G-104D AND G-106S ARE OF
COMPARABLE DEPTH.

FIGURE 2-11
WATER TABLE MAP
SHALLOW WELLS
JANUARY 29, 1991
LENZ OIL SITE

SYMBOL LEGEND:	
	PROPERTY LINE
	FENCE LINE
	RAILROAD
	WATER SURFACE
	EXISTING MONITORING WELL
	SURFACE WATER GAGE
WELL DEPTH NOTATION:	
D	DEEP WELL
G101L	INTERMEDIATE DEPTH WELL
M,L AND S	SHALLOW WELL





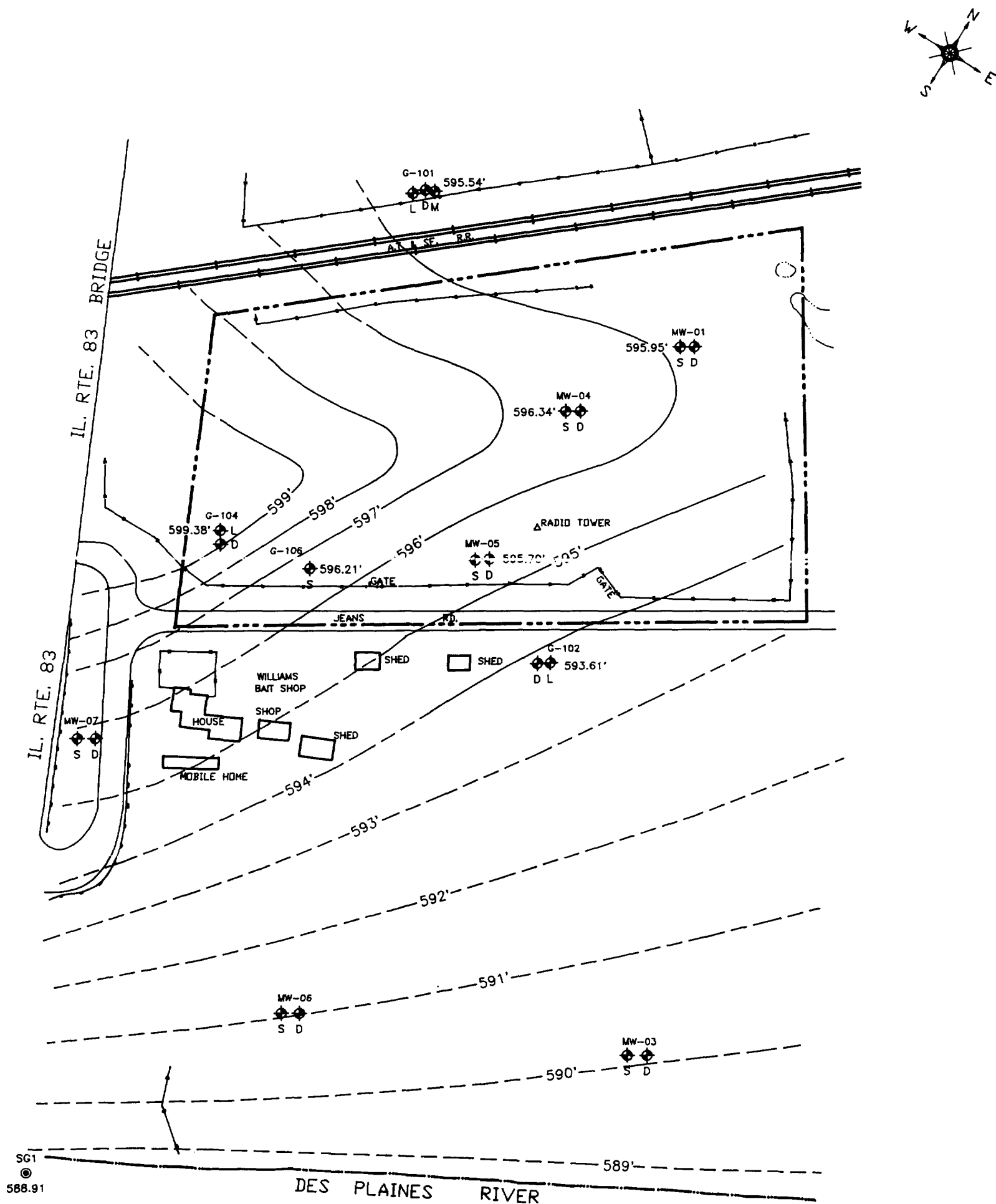
APPROX. SCALE (ft.)

0 120

NOTE:
SOUNDING OF WELLS ON 1/29/91
INDICATED THAT WELLS G-101M, G-102L
G-104L, G-104D AND G-106S ARE OF
COMPARABLE DEPTH.

FIGURE 2-12
WATER TABLE MAP
SHALLOW WELLS
FEBRUARY 26, 1991
LENZ OIL SITE

SYMBOL LEGEND:	
	PROPERTY LINE
	FENCE LINE
	RAILROAD
	WATER SURFACE
	EXISTING MONITORING WELL
	SURFACE WATER GAGE
WELL DEPTH NOTATION:	
D	DEEP WELL
G101L	INTERMEDIATE DEPTH WELL
M,L AND S	SHALLOW WELL



APPROX. SCALE (ft.)
0 120

FIGURE 2-13
WATER TABLE MAP
SHALLOW WELLS
MARCH 20, 1991
LENZ OIL SITE

SYMBOL LEGEND:	
	PROPERTY LINE
	FENCE LINE
	RAILROAD
	WATER SURFACE
	EXISTING MONITORING WELL
	SURFACE WATER GAGE
WELL DEPTH NOTATION:	
D	DEEP WELL
G101L	INTERMEDIATE DEPTH WELL
M, L AND S	SHALLOW WELL

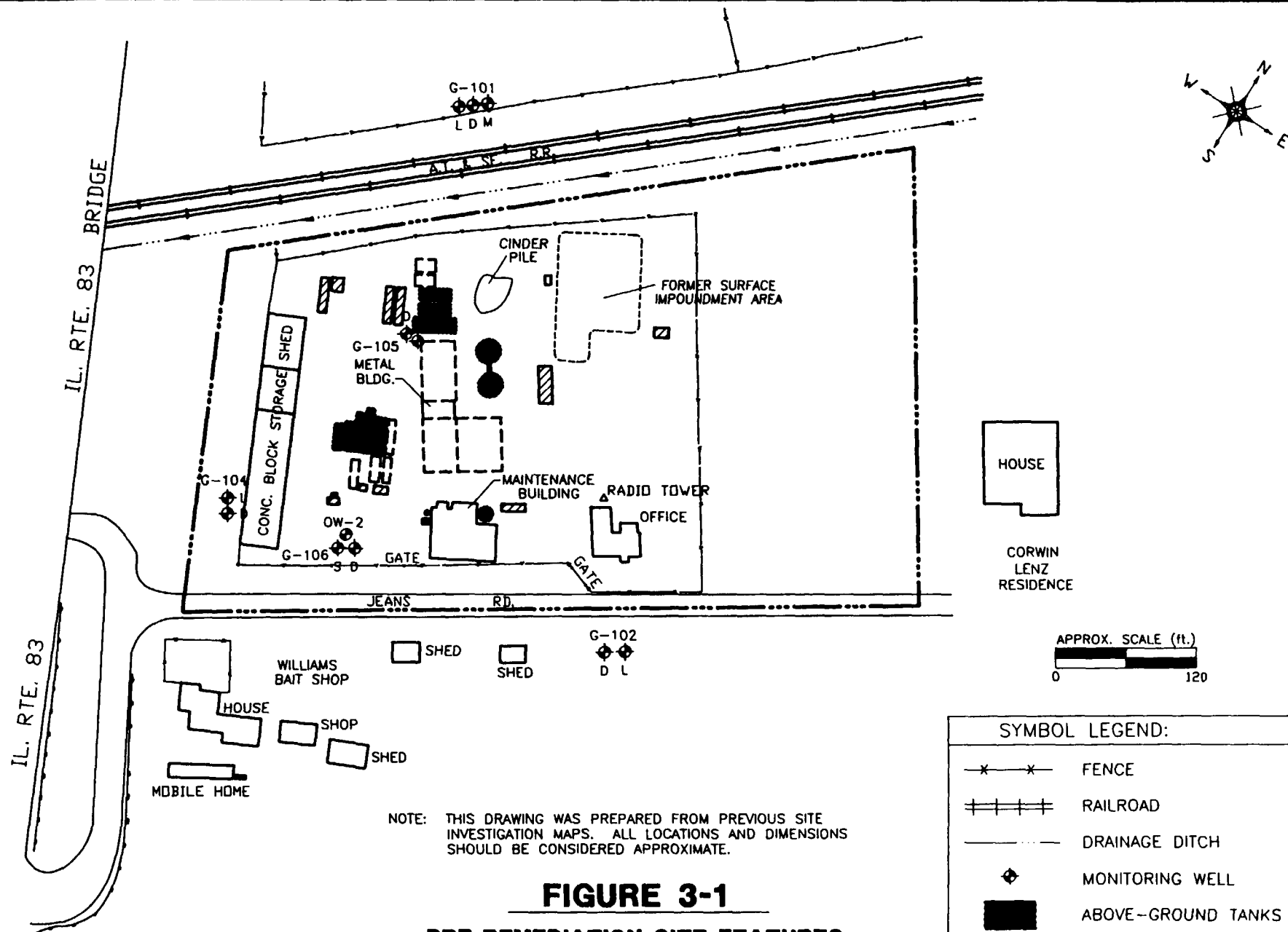


FIGURE 3-1
PRE-REMEDIATION SITE FEATURES
LENZ OIL SITE

SYMBOL LEGEND:	
— x — x —	FENCE
— + + + —	RAILROAD
— · · · —	DRAINAGE DITCH
◆	MONITORING WELL
■	ABOVE-GROUND TANKS
▨	TANK TRUCKS
- - -	BELOW-GROUND TANKS

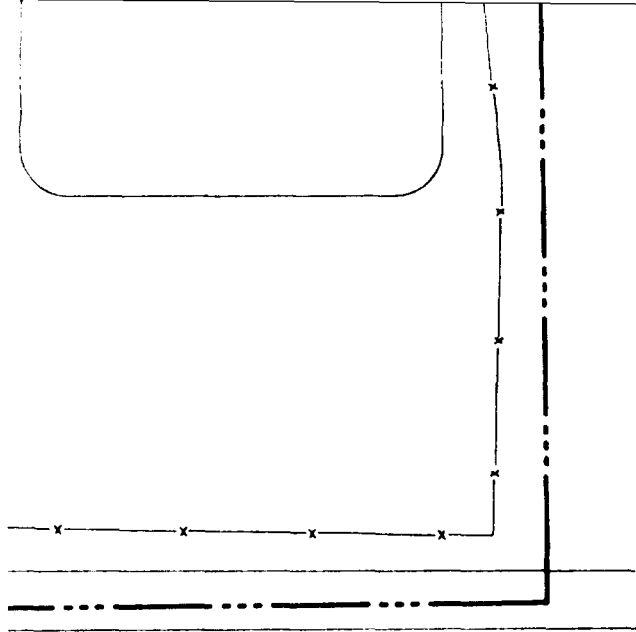
SDMS US EPA REGION V


FORMAT- OVERSIZED - 5

IMAGERY INSERT FORM

The item(s) listed below are not available in SDMS. In order to view original document or document pages, contact the Superfund Records Center.

SITE NAME	LENZ OIL		
DOC ID #	161202		
DESCRIPTION OF ITEM(S)	FIGURE 3-2		
REASON WHY UNSCANNABLE	<u> X </u> OVERSIZED	OR	<u> </u> FORMAT
DATE OF ITEM(S)	10/16/92		
NO. OF ITEM	1		
PHASE	REM		
PRP	RMD		
PHASE (AR DOCUMENTS ONLY)	<u> </u> Remedial <u> </u> Removal <u> </u> Deletion Docket <u> </u> AR <u> </u> Original <u> </u> Update # <u> </u> Volume <u> </u> of <u> </u>		
COMMENT(S)			



APPROX. SCALE (ft.)

 0 60
 NOT DRAWN TO SCALE

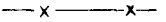
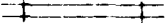
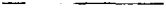




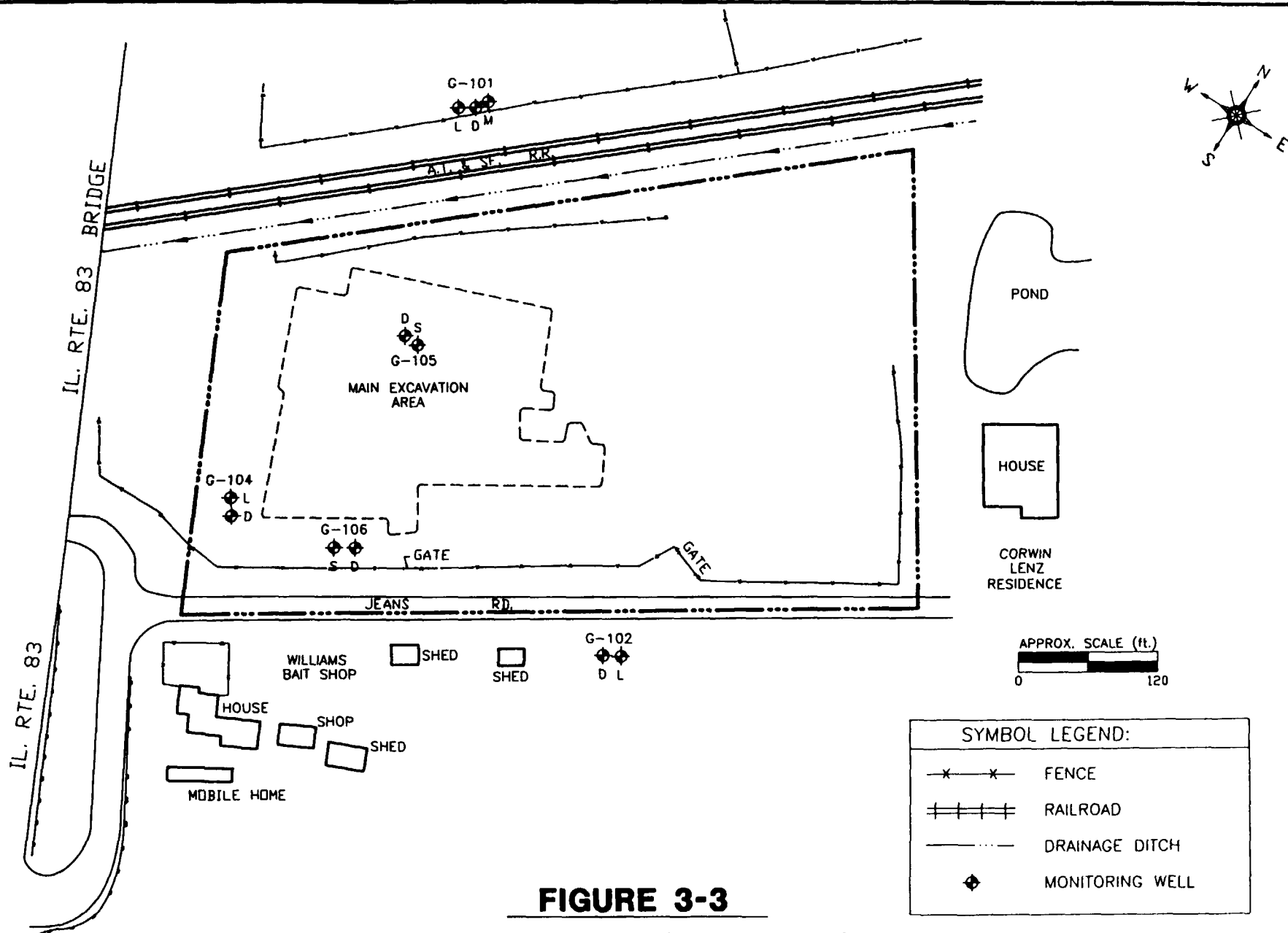
SYMBOL LEGEND:	
	FENCE
	RAILROAD
	DRAINAGE DITCH
X	SOIL SAMPLE LOCATIONS
D	DRUM
T	TANK
	MONITORING WELLS
	TANK TRUCKS
	ABOVE-GROUND TANKS
	BELOW-GROUND TANKS

FIGURE 3-2
SITE INVESTIGATION/REMEDATION
FEATURES MAP
LENZ OIL SITE



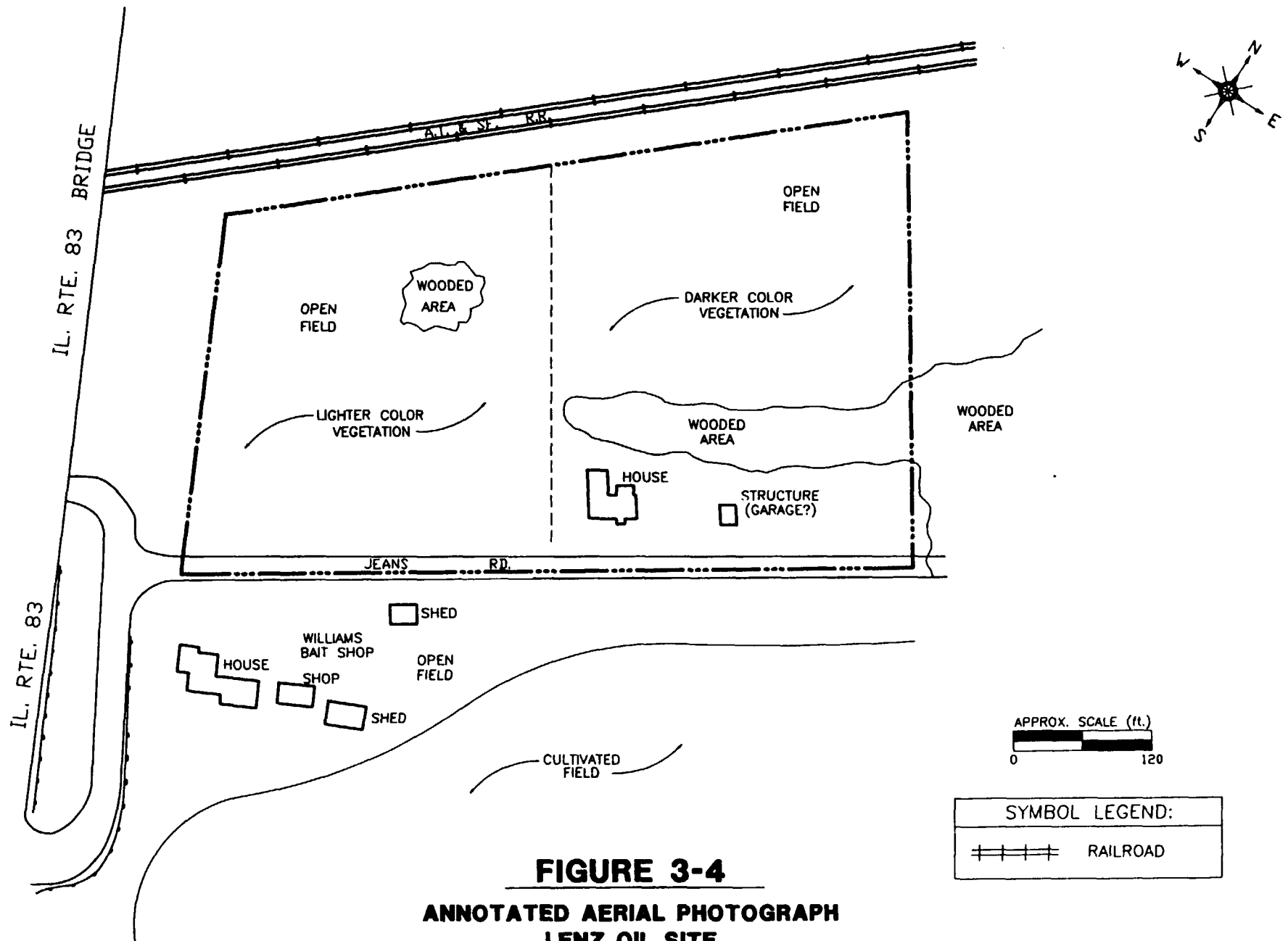


FIGURE 3-4

**ANNOTATED AERIAL PHOTOGRAPH
LENZ OIL SITE
OCTOBER 7, 1954**

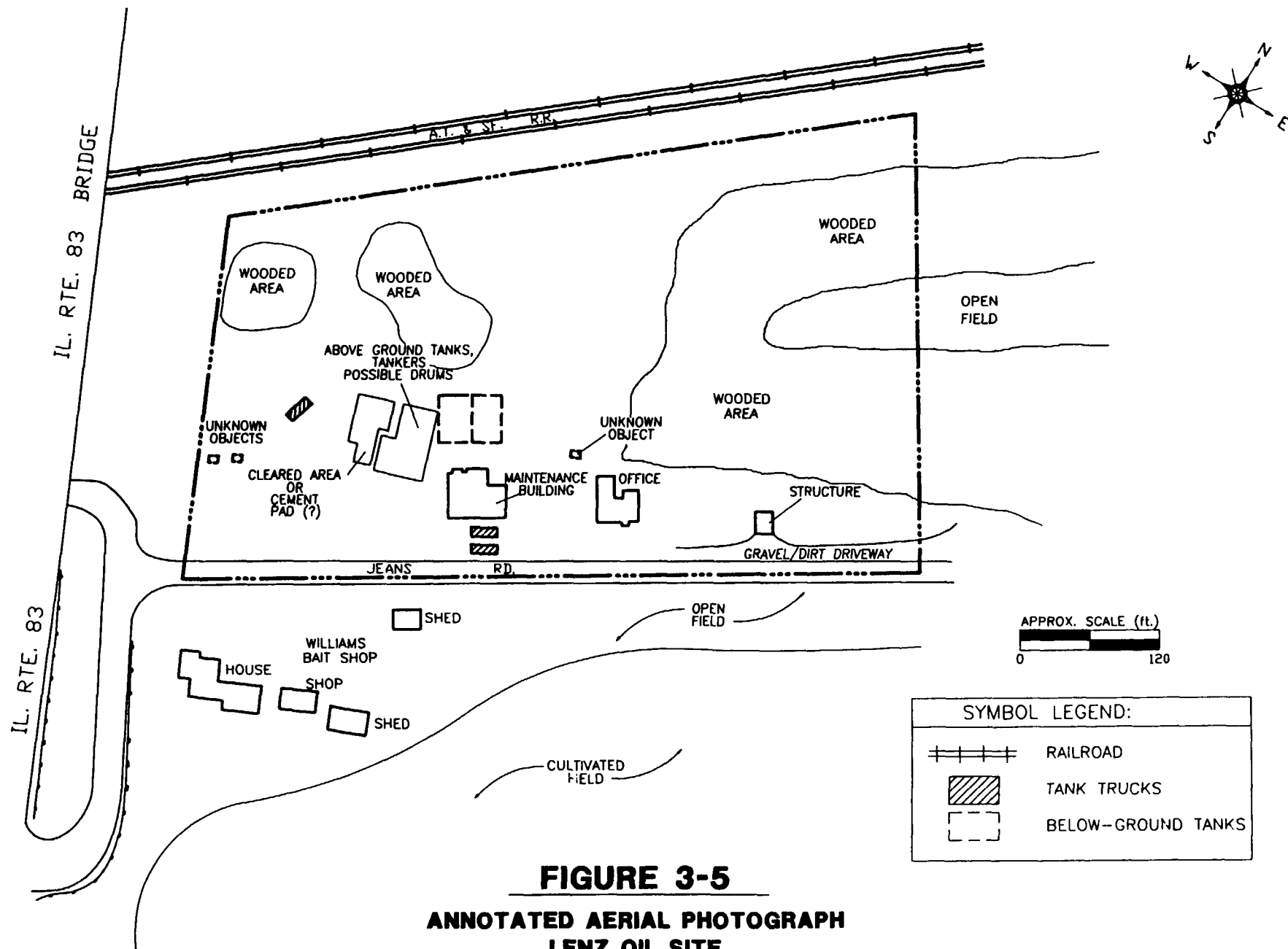
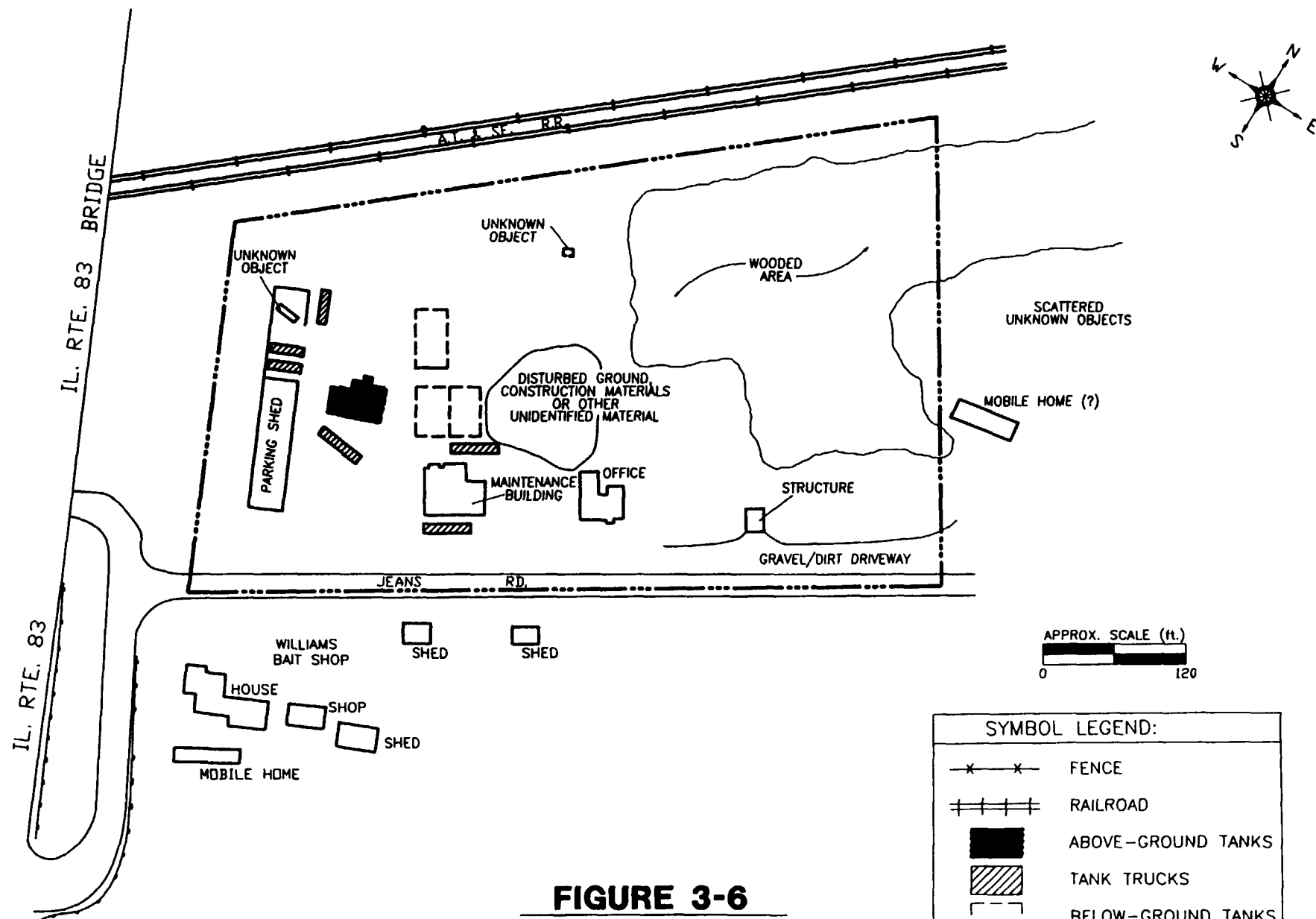


FIGURE 3-5

ANNOTATED AERIAL PHOTOGRAPH

LENZ OIL SITE

SEPTEMBER 6, 1961



SYMBOL LEGEND:	
	FENCE
	RAILROAD
	ABOVE-GROUND TANKS
	TANK TRUCKS
	BELOW-GROUND TANKS

FIGURE 3-6
ANNOTATED AERIAL PHOTOGRAPH
LENZ OIL SITE
SEPTEMBER 30, 1967

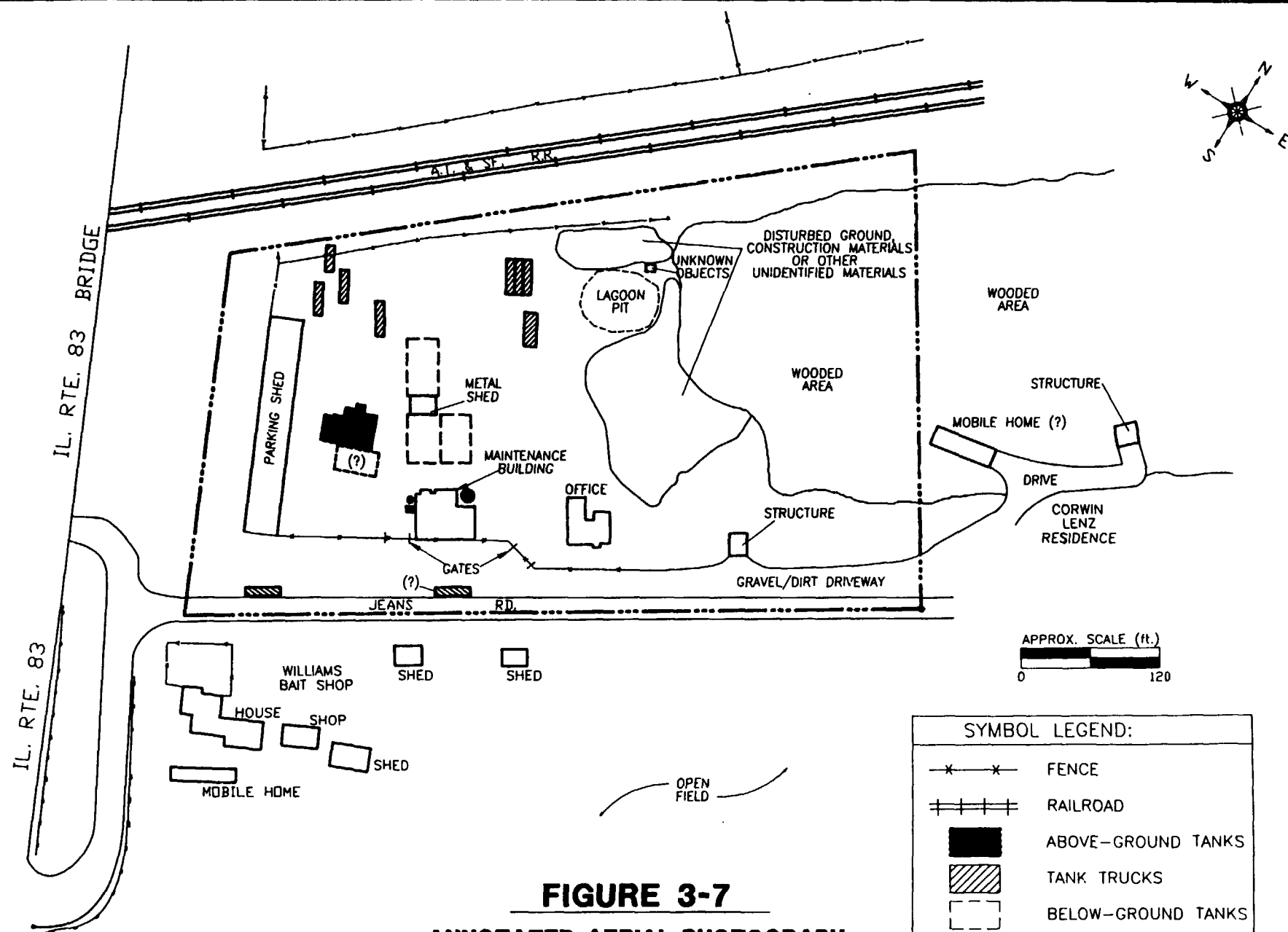
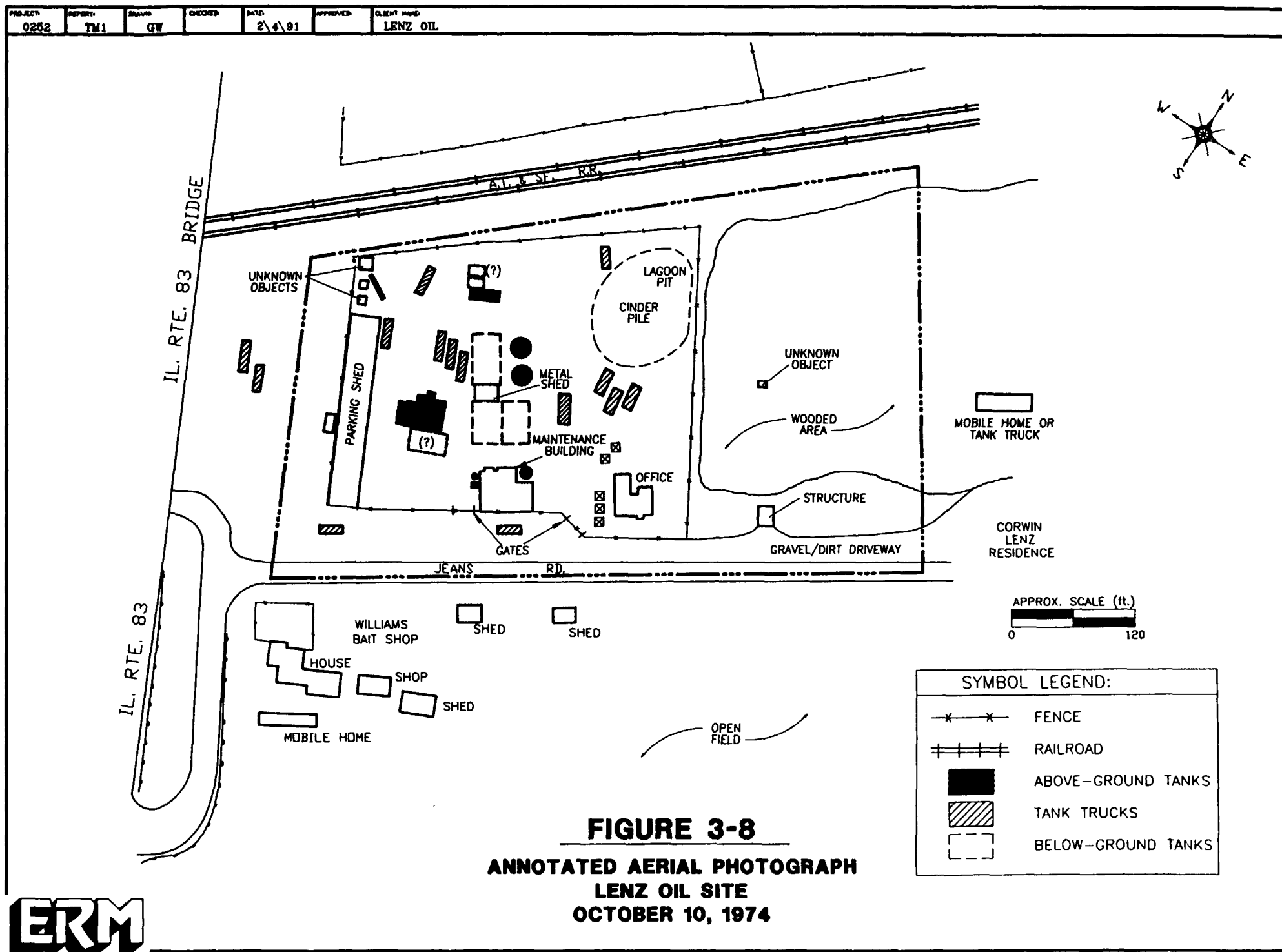


FIGURE 3-7

ANNOTATED AERIAL PHOTOGRAPH

LENZ OIL SITE

MAY 14, 1971



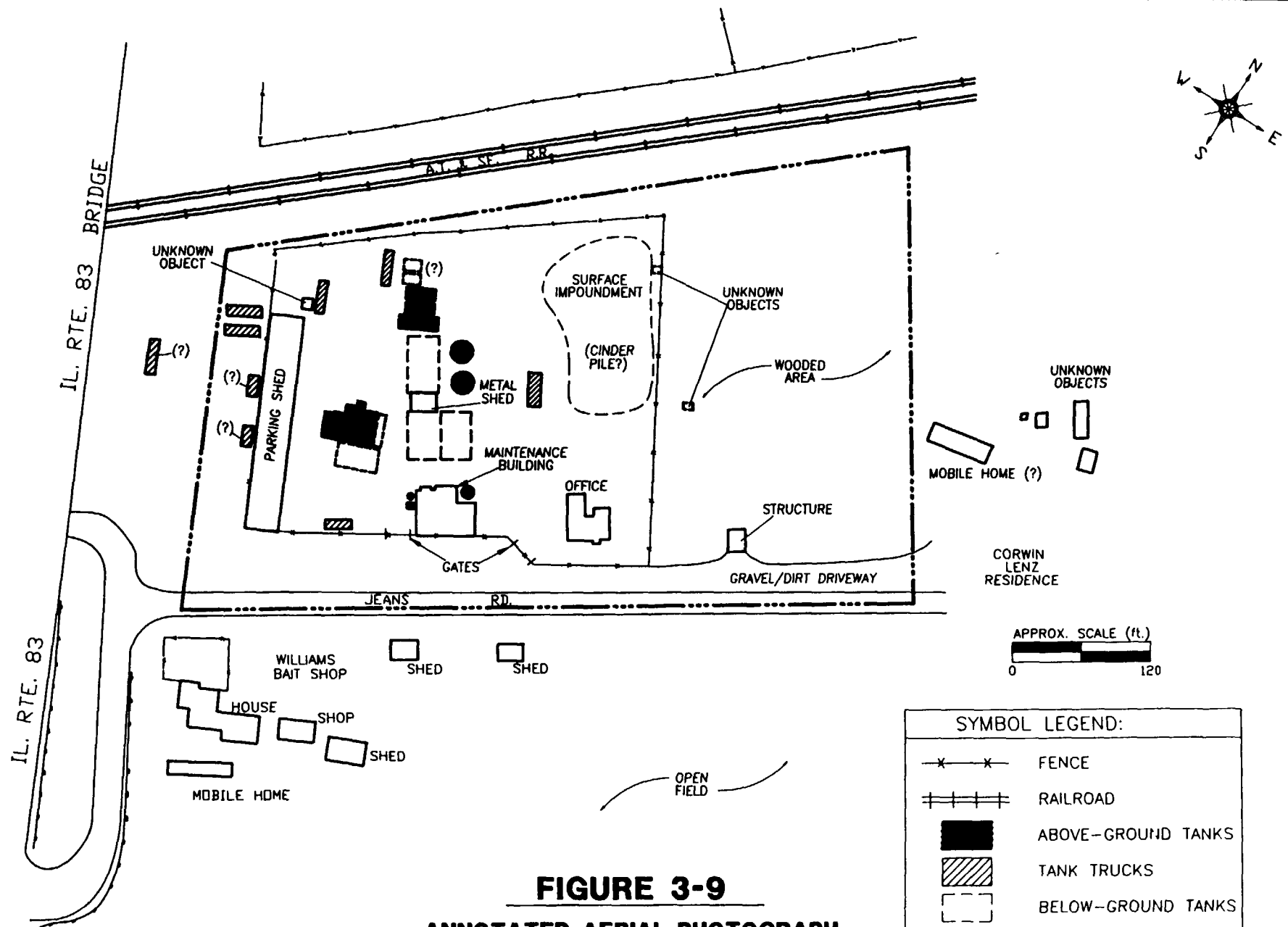
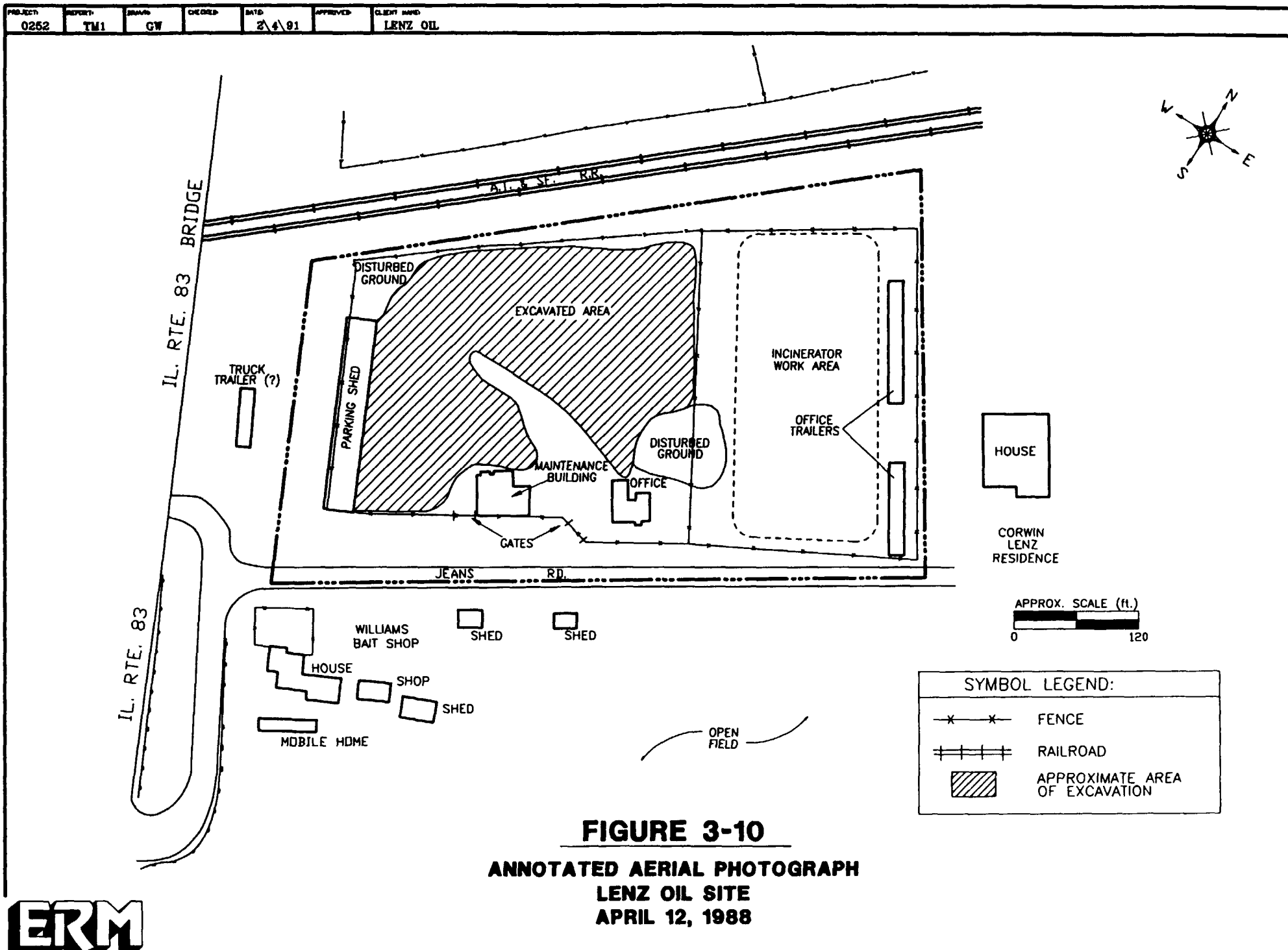
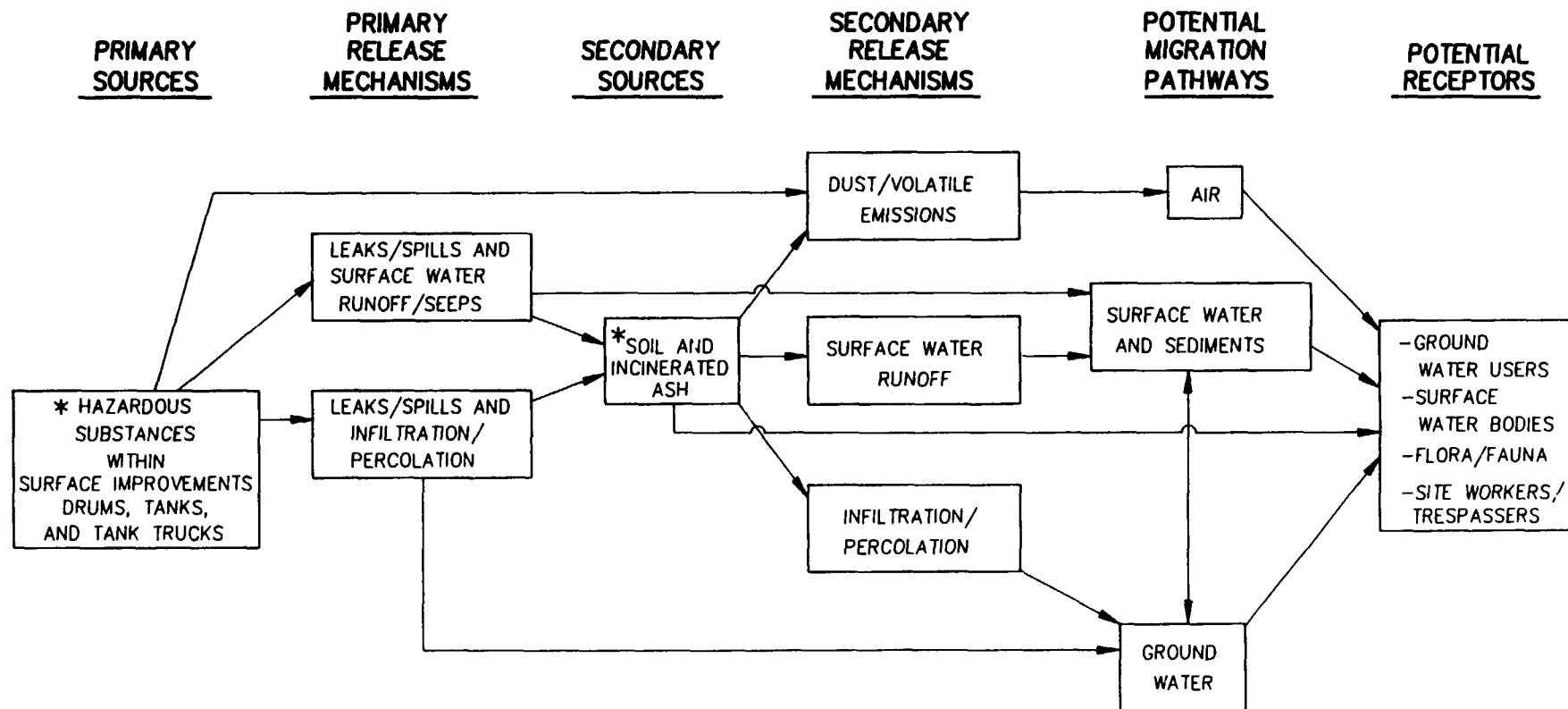


FIGURE 3-9
ANNOTATED AERIAL PHOTOGRAPH
LENZ OIL SITE
NOVEMBER 7, 1981





* SOURCES REMEDIATED BY IEPA BETWEEN 1986 AND 1988, RESIDUAL CONTAMINATION MAY REMAIN IN SOIL.

FIGURE 4-1
PRELIMINARY
CONCEPTUAL SITE MODEL
LENZ OIL SITE

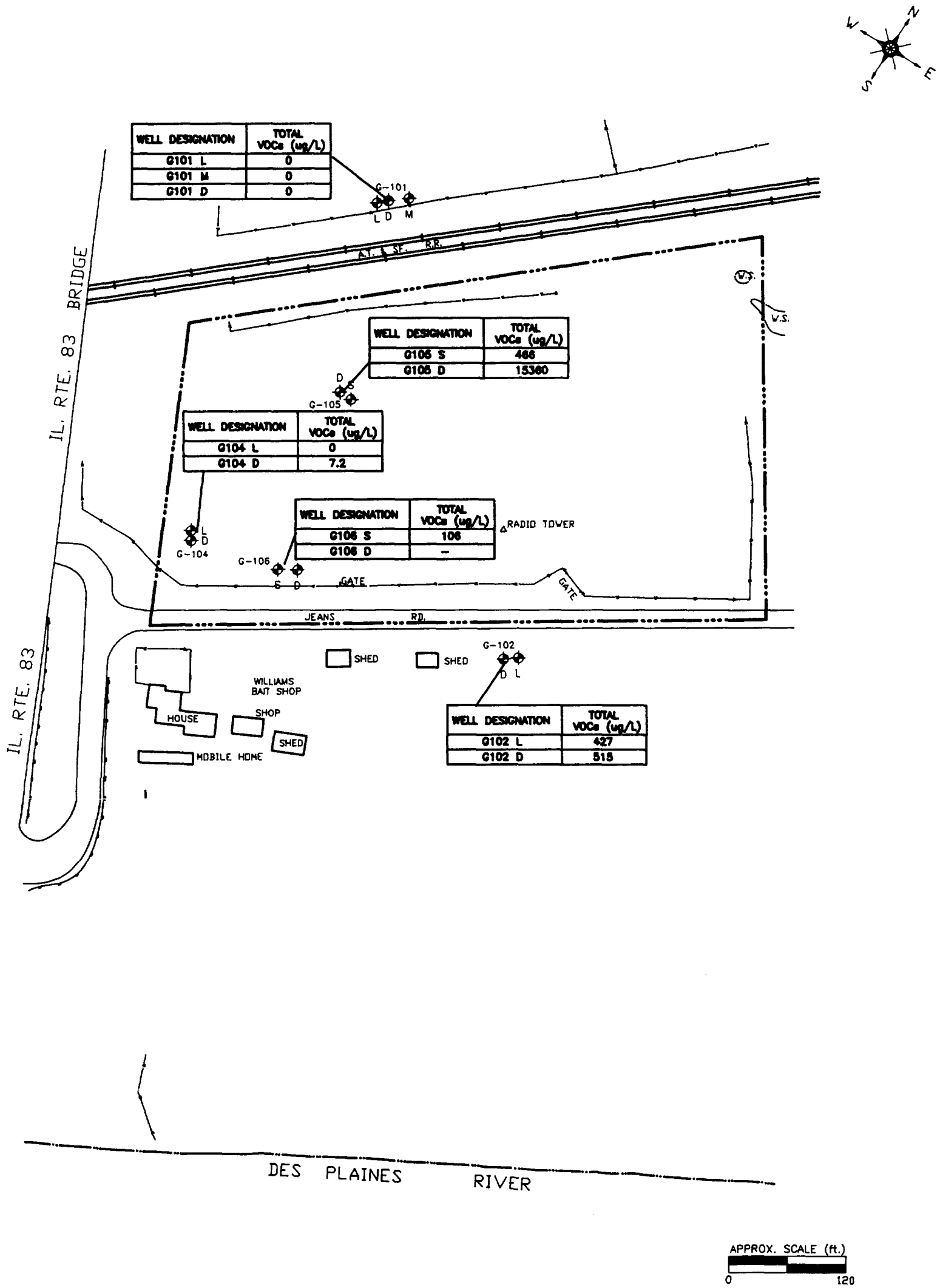


FIGURE 4-2
GROUND WATER ANALYTICAL RESULTS
LENZ OIL SITE

APPENDIX A
GEOLOGIC LOGS

OWNER Lenz Oil Service, Inc.	LOG OF BORING NUMBER OM-2
PROJECT NAME Ground-Water Monitoring Well Installation	
ARCHITECT-ENGINEER	

SITE LOCATION Route #1, Lemont, Illinois	<div style="border: 1px solid black; padding: 5px;"> </div>
--	---

ELEVATION		SAMPLE NO	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	SURFACE ELEVATION	UNIT DRY WT LBS / FT ³	UNCOMFINED COMPRESSIVE STRENGTH (TONS/FT ²)					
<input checked="" type="checkbox"/> DEPTH									1	2	3	4	5	
		1	PA			Crushed stone (Fill)	98.59							
			SS			"2"								
						Sandy silt, trace clay & gravel - lt. brown- dense - saturated (ML)								
						Strong chemical odor								
						Clayey silt, little sand, trace gravel -lt. brown & lt. gray- very dense - moist (ML-CL) moderate chemical odor								
						Sandy silt, trace clay & gravel - gray- very dense to extremely dense - moist (ML) moderate chemical odor - highly cemented at 10 ft								
		5	SS											
			PA											
						Sandy fine to med. limestone gravel, little clay & silt -lt. gray- dense - saturated (GC) Strong chemical odor								
		6	SS											
			PA											
						Refusal to power auger at 19.3 ft								
						END OF BORING								
						"A" - Silty fine to coarse sand, little gravel, trace clay & light brown- dense - moist (SI) Strong chemical odor								
						Installed 2" monitoring well at 19.3'								

WELL LOG WEL 12.01 BCR ACE WEL 12.01	WELL LOG WEL 12.01 BCR ACE WEL 12.01	WELL LOG WEL 12.01 BCR ACE WEL 12.01
SOIL TESTING SERVICES, INC. 111 PRINGSTEN ROAD NORTHBROOK ILLINOIS 60062		
APP'D BY RGS STS JOB NO 20102		



Illinois Environmental Protection Agency

BORING NO. 101	WELL NO. 101-D	GROUNDLEVEL ELEV.	PAGE 1	OF 3				
COUNTY DuPage	SITE NO.	DATE 4/29/86	FINISH 4/29/86	ANNULUS FILL MATERIAL See well construction diagram				
SITE Lenz Oil		START TIME 900a	FINISH TIME 400pm	PACKING				
BORING LOCATION See Map				SCREEN				
DRILLING EQUIPMENT CME 73	SIZE 3 1/4"	TYPE Hollow Stem Augers						
COMPLETION DEPTH 38.00	BEDROCK DEPTH 25.3	TOP OF CASING +3.00						
WELL CASING 316 Stainless Steel	TYPE AND QUANTITY See well construction diagram							
SCREEN INTERVAL See well construction diagram								
ELEV	DESCRIPTION	DEPTH	SAMPLE NO.	SAMPLE TYPE	SAMPLE RECOVERY (%)	PENETROMETER (Strength)	N VALUE (Blows)	PERSONNEL L. Grede D. Boise H. Murphy, W. Delph, H. on

ELEV	DESCRIPTION	DEPTH	SAMPLE NO.	SAMPLE TYPE	SAMPLE RECOVERY (%)	PENETROMETER (Strength)	N VALUE (Blows)	REMARKS
0-0.6	Dark brown silt, grass roots.	0					~	
0.6-1.9	Brown clayey sandy silt with small gravel pebbles, some cobble size dolomite pieces.	1	SS	0.7			36	
1.9-6.6	Brown silt with some pebbles and gravel. Iron staining, blocky texture. Few spots of gray (unweathered) material.	2	SS	0.4			36	
		3					~	
		4	SS	1.1			78	
		5					~	
		6	SS	1.1			78	
6.6-9.2	Silty sand with pebbles and gravel. Light tan. Moist. Dolomite majority of gravel pieces, some sandstone also in pebble size pieces.	7	SS	1.2			78	
		8	SS	0.1			1523	
9.2-11.8	Silty gravel slight amount of sand, light tan to light brown. Blocky texture.	9	SS	1.4			3041	
		10					~	
		11	SS	1.5			3747	
11.8-12.9	Silty dolomitic gravel-gray. slight clay, and CaCO ₃ uncrushed blocky texture, well consolidated.	12					~	
12.9-17.6	Brown silty sand with pebbles and gravel, light brown. Slight CaCO ₃ content. Fine to coarse sand.	13	SS	1.2			5047	
		14					~	



Illinois Environmental Protection Agency

BORING NO 101		WELL NO 101-D		GROUNDLEVEL ELEV		PAGE 2 3			
COUNTY DuPage		SITE NO		DATE 4/29/86 7/15/86		ANNUOUS FILL MATERIAL ABOVE PACKING			
SITE Lenz Oil				TIME 9a 4p		PACKING			
BORING LOCATION See Map		SIZE CME 75 3 3/4" Hollow Stem Auger		FINISH		SCREEN			
COMPLETION DEPTH 38.00		BEDROCK DEPTH 25.3		TOP OF CASING +3.00					
WELL CASING See well construction diagram		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
SCREEN INTERVAL		TYPE AND QUANTITY						L. Grede D. Boice H. Murphy, Del. 1/8/86	
ELEV	DESCRIPTION	DEPTH	Sample No	Sample Type	Sample Recovery (%)	Penetration (Strength)	N Value (Blows)	REMARKS	
		14		SS	10		44		
		15					29		Wet.
		16		SS	10		15		
		17					13		
		18		SS	11		10		
		19					9		
		20		SS	01		14		
		21					8		
		22		SS	12		13		
		23					15		
		24		SS	13		18		
		25					28		
		26		SS	11		22		
		27					31		
		28		CS	13				
		29							
		30							
		31							
		32							
		33							
		34							
		35							
		36							
		37							
		38							
		39							
		40							
		41							
		42							
		43							
		44							
		45							
		46							
		47							
		48							
		49							
		50							
		51							
		52							
		53							
		54							
		55							
		56							
		57							
		58							
		59							
		60							
		61							
		62							
		63							
		64							
		65							
		66							
		67							
		68							
		69							
		70							
		71							
		72							
		73							
		74							
		75							
		76							
		77							
		78							
		79							
		80							
		81							
		82							
		83							
		84							
		85							
		86							
		87							
		88							
		89							
		90							
		91							
		92							
		93							
		94							
		95							
		96							
		97							
		98							
		99							
		100							
		101							
		102							
		103							
		104							
		105							
		106							
		107							
		108							
		109							
		110							
		111							
		112							
		113							
		114							
		115							
		116							
		117							
		118							
		119							
		120							
		121							
		122							
		123							
		124							
		125							
		126							
		127							
		128							
		129							
		130							
		131							
		132							
		133							
		134							
		135							
		136							
		137							
		138							
		139							
		140							
		141							
		142							
		143							
		144							
		145							
		146							
		147							
		148							
		149							
		150							
		151							
		152							
		153							
		154							
		155							
		156							
		157							
		158							
		159							
		160							
		161							
		162							
		163							
		164							
		165							
		166							
		167							
		168							
		169							
		170							
		171							
		172							
		173							
		174							
		175							
		176							
		177							
		178							
		179							
		180							
		181							
		182							
		183							
		184							
		185							
		186							
		187							
		188							
		189							
		190							
		191							
		192							
		193							
		194							
		195							
		196							
		197							
		198							
		199							
		200							
		201							
		202							
		203							
		204							
		205							
		206							
		207							
		208							
		209							
		210							
		211							
		212							
		213							
		214							
		215							
		216							
		217							
		218							
		219							
		220							
		221							
		222							
		223							
		224							
		225							
		226							
		227							
		228							
		229							
		230							
		231							
		232							
		233							
		234							
		235							
		236							
		237							
		238							
		239							
		240							
		241							
		242							
		243							
		244							
		245							
		246							
		247							
		248							
		249							
		250							
		251							
		252							
		253							
		254							
		255							
		256							
		257							
		258							



Illinois Environmental Protection Agency

BORING NO 101		WELL NO		GROUNDLEVEL ELEV		PAGE 3 3			
COUNTY DuPage		SITE NO		DATE 4/24/86		FINISH 4/29			
BORING LOCATION See Map		DRILLING EQUIPMENT See first page		TIME 9a		FINISH 4p			
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING		SCREEN			
WELL CASING		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
SCREEN INTERVAL		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
ELEV	DESCRIPTION	DEPTH	Sample No	Sample Type	Sample Recovery (%)	Penetration (Strength)	N Value (blows)	REMARKS	
	see previous page for bedrock description	28							
		29							
		30							
		31							
		32							
		33							
		34							
		35							
		36							
		37							
		38						EOB.	



Illinois Environmental Protection Agency

BORING NO. 102		WELL NO.	GROUNDLEVEL ELEV.		PAGE 1 2			
COUNTY DuPage		SITE NO.	START DATE 4/15/86	FINISH DATE 4/15/86	ANNULUS FILL MATERIAL ABOVE PACKING			
SITE Lemont - Lene Oil			START TIME 1000a	FINISH TIME 400p	PACKING			
BORING LOCATION ~25' E of SE corner of Lene Property, across road					SCREEN			
DRILLING EQUIPMENT CME 75 3 1/4 H.S.A								
COMPLETION DEPTH 19.2	BEDROCK DEPTH 6.7	TOP OF CASING						
WELL CASING	TYPE AND QUANTITY		SAMPLES			PERSONNEL		
SCREEN INTERVAL		TYPE AND QUANTITY	Sample No	Sample Type	Sample Recovery Ft	Penetration (Strength)	N Value (Blows)	REMARKS
ELEV	DESCRIPTION		DEPTH					
	0-0.55	Dark brown silt, grass, roots, little clay	0					
	0.55-0.75	Sandy silt with gravel - brown						
	0.75-6.1	Silty gravel (dolomite and sandstone) with varying concentrations of sand, gravel, and silt. Dry. CaCO ₃ present. Cabbles and boulders of dolomite (2.4 to 2.6, 5.0 to 5.8). Light tan to light brown. Iron stains present from 2.6 to 3.9.	1	SS	1.1		3	
			2				19	
			3				37	
			4	SS	1.9			
			5					
			6	SS	1.9		36	
			7				53	
			8				35	
	6.1-6.7	Grey gravelly clayey silt dolomite gravel, small amounts of sand.	6					
	6.7-19.2	Dolomite - light gray, secondary porosity from fractures and solutioning. Silt nodules prominent from 17.1 to 19.2. Vertical (high angle) and horizontal fractures	7	SS	1.0			
			8					
			9					
			10					
			11					
			12					
			13					
			14					
				CORE BARREL	9.9			
								augered to 7.3' to set augers for coring.



Illinois Environmental Protection Agency

BORING NO 102		WELL NO	GROUNDLEVEL ELEV		PAGE 2 OF 2			
COUNTY		SITE NO	DATE	FINISH	ABOVE PACKING			
SITE Dupage			4/15/86	4/15				
BORING LOCATION ~25' E of SE corner of Lene Property, across road			START TIME	FINISH	PACKING			
DRILLING EQUIPMENT CME 75 3 1/4" HSA 3 1/4 core barrel Christensen		SIZE	1000	1000				
COMPLETION DEPTH 19.2	BEDROCK DEPTH 6.7	TOP OF CASING			SCREEN			
WELL CASING	TYPE AND QUANTITY		SAMPLES			PERSONNEL		
SCREEN INTERVAL		TYPE AND QUANTITY	Sample No	Sampler Type	Sample Recovery %	Permeability (Strength)	N Value (Blow)	REMARKS
ELEV	DESCRIPTION		DEPTH					
	See previous page for description		14					
			15					
			16					
			17					
			18					
			19					
			20					EOB 19.2'



Illinois Environmental Protection Agency

BORING NO.		WELL NO.		GROUNDLEVEL ELEV.		PAGE		SF	
103						1		1	
COUNTY		SITE NO.		DATE		FINISH		ANNULUS FILL MATERIAL	
DuPage				4/14/86		4/14/86		-	
SITE				START		FINISH		ABOVE PACKING	
Lemont Lenz Oil				4/14/86		4/14/86		-	
BORING LOCATION				TIME		FINISH		PACKING	
Williams Bait Shop				920a		1100a		-	
DRILLING EQUIPMENT		SIZE		TYPE				SCREEN	
CME 75 3 3/4" H.S.A		24"		Split Spoon Sampler				-	
COMPLETION DEPTH		BEDROCK DEPTH		TOP OF CASING					
5.7		5.6							
WELL CASING		TYPE AND QUANTITY							
SCREEN INTERVAL		TYPE AND QUANTITY							
ELEV		DESCRIPTION		DEPTH		Sample No		PERSONNEL	
						Sample Type		L. Grede	
						Sample Recovery Ft		D. Bosio	
						Penetration (Strength)		H. Murphy, Adelphi	
						N Value (Blows)		REMARKS	
0-0.4		Dark brown silt, with organics, roots. Moist		0					
0.4-2.0		Light brown sandy silt, medium grained sand, some pebbles. Moist. Few gravel pieces. R.O.C.		1		SS 0.9		1	
								3	
								3	
2.0-3.0		Light tan silty sand. Small pebbles and some gravel. Dry. Fine to medium gr. sand. Light Brown 2.6 to 3.0, some composition.		2					
3.0-5.6		Light brown sandy silt, CaCO ₃ abundant. Dolomite pebbles and gravel. Faint chemical odor at 4.4. Dry. Hard. Dolomite boulder at 4.0 to 4.3.		3		SS 1.6		19	
				4				40	
				5		SS 1.7		84	
				6				48	
								95	
								100	
5.6-5.7		Light gray dolomite, fine grained, no fractures apparent. Split spoon refusal at 5.7.						EOB 5.7	



Illinois Environmental Protection Agency

BORING NO. 104		WELL NO.	GROUNDLEVEL ELEV.		PAGE 1		OF 1		
COUNTY DuPage		SITE NO.		START DATE 5/13/86	FINISH DATE 5/13/86	ANNULUS FILL MATERIAL ABOVE PACKING			
BORING LOCATION See map		DRILLING EQUIPMENT CME 75 6 1/4" Hollow Stem Augers		START TIME 900c	FINISH TIME 1030a	PACKING			
COMPLETION DEPTH 3.9	BEDROCK DEPTH 3.4	TOP OF CASING		SCREEN		PERSONNEL			
WELL CASING		TYPE AND QUANTITY		SAMPLES				PERSONNEL	
SCREEN INTERVAL		TYPE AND QUANTITY		Sample No.	Sampler Type	Sample Recovery ft.	Penetration (lb/inch)	N Value (blows)	REMARKS
ELEV.	DESCRIPTION			DEPTH					
	0-0.4 Dark brown silt with gravel, very oily smell.								
	0.4-1.6 Dolomite cobbles in med to fine grained sand, tan.				SS	0.6		7	
	1.6-3.4 Clayey silt with gravel and cobbles. very light brown. 1.6-1.9 layer of pea gravel with silt.							7	
	3.4 Dolomite - light gray where fresh, buff where not dry.				SS	1.0		14	
								28	
					SS	0.4		100	EOB.

CLIENT IEPA
PROJECT LEAD OIL, LEMONT ILLINOIS
SITE
LOCATION BEARING
CONTRACTOR CANONITE DRILLING
METHOD SOIL 6.25 INCH I.D. MOLLON SYSTEM
OF BORING: ROCK MIX GRILL, BEAM 12 3/8"

JOB NO. 06369 HOLE NO. 564 SHEET NO. 1 OF 3
WEATHER HOT, HUMID INSPECTOR A. BLANKEN
TEMP. 90 °F STARTED 6:00 A.M. 7/29 1986
DIP FINISHED 9:00 A.M. 7/21 1986
ELEVATIONS: DATUM
CASING DIAM. 6 I.D. DRILL PLATFORM
CORE DIAM. 1 1/2 GROUND SURFACE
WATER LEVELS

LOG LEGEND	SAMPLE CONDITION	SAMPLING METHOD	SHIPPING CONTAINER
- SILT	- SAND	- GOOD	- DISTURBED
- CLAY	- GRAVEL	- FAIR	- LOST
		A - SPLIT TUBE	E - AUGER
		B - THIN WALL TUBE	F - WASH
		C - PISTON SAMPLER	K - SLOTTED SAMPLER
		D - CORE BARREL	
			N - INSERT
			O - TUBE
			P - WATER CONTENT TIN
			Q - GLASS JAR
			R - CLOTH BAG
			S - PLOFILM BAG
			T - CORE BOX
			X - DISCARDED

LOG	DESCRIPTION: COLOR; CONSISTENCY DENSITY; TEXTURE; STRUCTURE; SHAPE AND SURFACE CONDITION OF GRAINS; ODOR; ETC.	ELEV. - DEPTH	SAMPLE TYPE	NO.	SIZE (IN.)	RETD. (IN.)	BLOWS PER 6 INCH	NOTES: BORING; TESTING AND SAMPLING PROCEDURES; WATER LOSS AND GAIN; DRILLING AND TESTING EQUIPMENT; ETC.
	0-6" SM. L. BROWN SILTY SAND		AQ	401	24	10	36 FOR	
	6-8" SM. CLAY SILTY SAND	1.0						
	8-10" PEA GRAVEL WITH SILT						1.5 FT	WHITE
	0-10" ML (RED) GRAY SILT	2.0	AQ	402		10	34	NO OBVIOUS SILT SEPARATION
	10-12" DR. V. VERY STIFF	3.0						PICTURE (P) #18
	0-4" ML. SAND P. FINE	4.0	AQ	403		4	PUSHED	
		4.0						P=19
	0-11" ML. DARK BROWN SILT	5.0	AQ	404		11	PUSHED	OVA HOLE > 1000 PPM, OVA B.Z. = 30
	CLAY, MED. STIFF						PUSHED	40 PPM, OVA JAR SAND > 1000
	NO SILT, MED. (FILL?)	6.0					22	P=20
	0-6" ML. GRAY CLAY SILT		AQ	405		6		OVA HOLE > 1000, OVA JAR = 600
	NO PEBBLES, PIECE OF WOOD	7.0					31	NO OBVIOUS SILT SEPARATION
	1 FT. BOTTOM OF CL. SPOON, STIFF							P=21
	0-2" ML. POORLY SORTED	8.0	AQ	406		2	30	OVA HOLE > 1000, OVA JAR > 1000
	CLAY, MED. STIFF, PEBBLES FINE	9.0						BLACK LIQUID IN SPIN, 1000 OF WATER
	0-3" ML. SPARSE BROWN SILTY CLAY		AQ	407		8	48	OVA HOLE > 1000, OVA SPAN = 40, B.Z. = 30 PPM. LIQUID IN SEPARATE INTO
	TOP SOIL (?)	10.0						MED. BROWN LIQUID AND BLACK LIQUID. PUT IN COMPOSITE SAMPLE
	0-3" GR. PEBBLES WITH PIECE OF WOOD							
			AQ	408		4	60	OVA HOLE > 1000, OVA JAR > 1000 P=24
	0-4" ML. GRAY SILTY CLAY							LIQUID MED. BROWN TO BLACK
	W/2 PEBBLES							P=25
	4-10" DOLOMITE ROCK FRAGMENT		AQ	409		10	57	OVA HOLE > 1000, OVA JAR = 100 PPM
	1/2 ROCK (?)							NO OBVIOUS STRAINING OF ROCK FRAGMENT



WEHRAN ENGINEERING
CONSULTING ENGINEERS

Field Borehole Log

JOB NO. 6529 HOLE NO. 564 SHEET NO. 2 OF 3

0-2" PORE FRAGMENT	14	X	AQ	4	3	B2	OVA HOLE = 700 OVA SWN = 80 F = 0
	15	X	AQ	4			1100 BUTT'S STATION - 101 F. R
0-2" PORE FRAGMENT	16	X	AQ	4	2	112	OVA HOLE 2000 OVA SWN 7.0 F = 27
							LEAVED FROM 1000 F. R. 101 F. R
							OVA SWN = 540
SET CATION							
FIRST RUN 5.4' (17.5-22.9)	25						OVA HOLE 21000 FPM
30% RECOVERY							OVA BREAKING = 216 = 201 FPM
GRAY LITESTONE WITH							PEAKING TO 52 FPM
ARMILLARIES PARTIAL							NO OBVIOUS OIL STAINING
HIGHLY FRACTURED							ROCK. ROCK STAINED
CONCRETE SOLID PEELE							RUSTY DRILL CEILING
6" FRAGMENTAL FINE							LEFT IN CORE CAPILL
TISSUE FROM FINE							OVERNIGHT (7)
GRAVEL TO 2" LONG							100% WATER LOSS
17.5-20.0' SURFACE ST							
CORE AND FRAGMENT							
PEELED (100% FINE)							
20-21' 4' HORIZONTAL							
11' 100% PER FOOT BLACK							
STAIN							
21-22.9' Rock FRAGMENT							
SECOND RUN 5.7' (22.9-28.6)							
390% RECOVERY							
22.9-25.4 SAME AS ABOVE							
25.4-26.2 4" PIECES							
3 EVENLY SPACED HORIZ							
CUTS FRACTURES STAINED							
BLACK							
26.2-27.0 HIGHLY FRACTURED							
PIECE & BRINE FROM 0.5-3.0'							
~0.5 INCH DIAM. BLACK NODULE							
IN FORM 22.28.6 SOLID							
CORE BROKEN IN 4 PLACES							
ALONG STEEPLY INCLINED FRACT							
URES. 1 FRACTURE SMOOTHING							
PLASTER, NO STAINING							
OTHER STAINING							



1105

JOB NO. 06369 HOLE NO. SB4 SHEET NO 3 OF 3

[illegible]

CLIENT ELIOT FPA
PROJECT LEAK OIL
SITE _____
LOCATION _____ BEARING _____
CONTRACTOR SHADILE CONSTRUCTION
METHOD SOIL 6.25 HOLLOW STEM PNEUM.
OF BORING: ROCK 1 1/2" DIA. 3' DEEP. OVER DRILL

JOB NO. 06269 HOLE NO. SB3/1106 SHEET NO. 1 OF 2
WEATHER HOT, HUMID INSPECTOR A. BLACKMAN
TEMP. 90 °F STARTED 11:00 A.M. 7/16 1986
DIP _____ FINISHED 9:30 A.M. 7/18 1986
ELEVATIONS: DATUM _____
CASING DIAM. _____ DRILL PLATFORM _____
CORE DIAM. _____ GROUND SURFACE _____
WATER LEVELS _____

LOG LEGEND		SAMPLE CONDITION		SAMPLING METHOD		SHIPPING CONTAINER	
	- SILT		- SAND		- GOOD		- DISTURBED
	- CLAY		- GRAVEL		- FAIR		- LOST
A - SPLIT TUBE		E - AUGER		N - INSERT		R - CLOTH BAG	
B - THIN WALL TUBE		F - WASH		O - TUBE		S - PLOFILM BAG	
C - PISTON SAMPLER		K - SLOTTED SAMPLER		P - WATER CONTENT TIN		Y - CORE BOX	
D - CORE BARREL		Q - GLASS JAR		Z - DISCARDED			

LOG	DESCRIPTION: COLOR; CONSISTENCY DENSITY; TEXTURE; STRUCTURE; SHAPE AND SURFACE CONDITION OF GRAINS; ODOR; ETC.	ELEV. - DEPTH	SAMPLE					BLOWS PER INCH	NOTES: BORING; TESTING AND SAMPLING PROCEDURES; WATER LOSS AND GAIN; DRILLING AND TESTING EQUIPMENT; ETC.
			NO.	SIZE (IN.)	RETD. (IN.)	TYPE	NO.		
	0-11" GP. POORLY SORTED. FINE SAND TO FINE GRAVEL. FRAGMENTS ARE SUBANGULAR; BOTTOM 2" MOIST	1	AG	58	24	11	10	10	OVA HOLE > 1000 PPM, OVA JAR 400 PPM
							9	9	NO PICTURE, DROPPED CAMERA
							9	6	
	0-3" GP. SAME AS ABOVE. SATURATED; 3-7" ML. DARK BROWN CLAY SILT, STIFF, MOIST; 7-12" SANDY DIOMITE FCK FRAGMENTS	2	AG	58	12	12	28	28	OVA HOLE > 1000 PPM, BREAMITAN ZON.
		3					14	14	1 PPM, SAMP. E JAR = 160 PPM
		4					14	6	
	0-19" ML. GRAY TO YELLOW - BROWN, ROOTED TO SILT WITH SOME CLAY; SUB. ANGULAR SMALL TO MED. PEBBLES, 19" ROCK FRAGMENTS	5	AG	3	19	19	13	13	OVA HOLE > 1000, B.Z. = 1 PPM
		6					43	43	FLUID IN SPON, SILT IS
		7					26	26	MOIST, NO OBVIOUS STAINING
	0-3" ML. YELLOW - BROWN SILT WITH ROCK FRAGMENTS	8	AG	4	15	15	16	16	OVA B.Z. = 1 PPM; OVA JAR = 460
		9					38	38	PEBBLES, SHARP CONTACT BETWEEN
	3-15" ML. GRAY SILT WITH ROCK FRAGMENTS, SUBROUNDED	10					29	29	YELLOW - BROWN AND GRAY SILTS; NO
		11					35	35	VISIBLE STAINING - SAMP
	0-14" ML. GRAY SILT WITH LARGE WEATHERED, HIGHLY FRAC- TURED (CRACKLE); OBVIOUS GEL SPREADING, MOIST	12	AG	5	14	14	24	24	BLACK OILY LIQUID MIXED WITH
		13					20	20	WATER DEPOSITED FROM (P. 11)
		14					27	27	OVA HOLE > 1000, B.Z. = 5-8 PPM
		15					31	31	OVA JAR > 1000
	0-3" ML. GRAY SILT WITH ROCK FRAGMENTS; 3-9" DARK GRAY ROCK FRAGMENTS; 9-17" DOLO- MITE (?) ROCK FRAGMENTS	16	AG	6	17	17	46	46	OVA HOLE > 1000 PPM; OVA JAR = 240
		17					18	18	SOME SILT; MOIST; NO OBVIOUS
		18					25	25	STAINING; OILY PHASE AP-
		19					33	33	PARENT IN AVERAGED CUTTINGS
	0-4" ROCK FRAGMENTS WITH SOME SILT. SAMPLE MOIST	20	AG	7	4"	4"	46	46	OVA JAR = 120 PPM, B.Z. = 8 PPM
	REFUSAL => BEDROCK(?)	21					100	100	
		22					3	3	END

BEDROCK (?)



JOB NO. 06369 HOLE NO. 583 / L106 SHEET NO 2 OF 2

DEPTH (FEET)	REMARKS	RECOVERY (%)	OTHER
0.0 - 6.1	ROCK HIT AFTER 6.1 FEET STREET COATING AT 6.1 FEET		
6.1 - 8.1	5.3' (6.1' TO 11.4') 6.1' TO 8.1' COMPLETELY LIMESTONE (?) OR IS INTERSTITIAL WITH TRANSISTIONS: TWO HORIZONTAL CRACKS, FINE (?), COLOR GRAY, UNWEATHERED	100% RECOVERY	DURING RATE OF CORING AT UNKNOWN BECAUSE OF BROKEN
8.1 - 11.0	8.1' TO 11.4' NO RECOVERY EXCEPT FOR A FEW LARGE PEBBLES. PEBBLES ARE ROUNDED BUT SOURCE OF ROUNDING NOT KNOWN, COULD BE DUE TO TRANSPORT OR CORING PROCESS	1-2% RECOVERY	DURING CORING RATE INCREASED DRASTICALLY 10% AFTER 11.0'
11.0 - 16.5	ROCK HIT AFTER AT 11.0' SECOND RUN 4.7' (11.8' TO 16.5') 11.8' - 16.5' HIGHLY FRACTURED; PIECES RANGE IN LENGTH FROM APPROX. 4" TO FINE GRAVEL SIZE FRAGMENTS MATERIAL APPEARS TO BE FOLIOLAR LIME STONE, DOLOSTONE (?), LIGHT GRAY	~60% RECOVERY	BLACK STAINING ON MANY FRACTURE SURFACES. ONE OBVIOUS SUBVERTICAL FRACTURE AT ~15' B.B.S. STAINED BLACK BLACK MINERALIZATION WITHIN ROCK (NODULES ~ 0.1" IN DIAM) DUA OF CORE = 0 PPM
16.5 - 17.0	END OF BORING		

CLIENT TULALUPES EPA
 PROJECT LEAK OIL
 SITE _____
 LOCATION (LATITUDE) (LONGITUDE) BEARING _____
 CONTRACTOR _____
 METHOD OF BORING: SOIL 3 3/4" HOLLOW STEM AUGER
 ROCK _____

JOB NO. 06369 HOLE NO. SB1 SHEET NO. 1 OF 2
 WEATHER WARM, RAINY INSPECTOR A. BLACKMER
 TEMP. 70 °F STARTED 11:30 A.M. 7/25 1986
 DIP _____ FINISHED 3:00 P.M. 7/25 1986
 ELEVATIONS: DATUM _____
 CASING DIAM. _____ DRILL PLATFORM _____
 CORE DIAM. _____ GROUND SURFACE _____
 WATER LEVELS _____

LOG LEGEND	SAMPLE CONDITION	SAMPLING METHOD	SHIPPING CONTAINER
- SILT	□ - SAND	□ - GOOD	□ - DISTURBED
- CLAY	□ - GRAVEL	□ - FAIR	□ - LOST
		A - SPLIT TUBE	E - AUGER
		B - THIN WALL TUBE	F - WASH
		C - PISTON SAMPLER	K - SLOTTED SAMPLER
		D - CORE BARREL	Q - GLASS JAR
			N - INSERT
			O - TUBE
			P - WATER CONTENT TIN
			R - CLOTH BAG
			S - PLOP/BAG
			T - CORE BOX
			Z - DISCARDED

LOG	DESCRIPTION: COLOR; CONSISTENCY DENSITY; TEXTURE; STRUCTURE; SHAPE AND SURFACE CONDITION OF GRAINS; ODOR; ETC.	ELEV. DEPTH	SAMPLE NO.	SIZE (IN.)	RETD. (IN.)	BLOWS PER 6 INCH	NOTES: BORING; TESTING AND SAMPLING PROCEDURES; WATER LOSS AND GAIN; DRILLING AND TESTING EQUIPMENT; ETC.
	2-7" BLACK SILT		AQ	SB 1	24	13	PUSH DRY
	7-13" ? STEFF BLACK MAT.						PUSH OVA HOLE > 1000 PPM
	ERIAL WITH SILT & BLACK ROCK FRAGMENTS, etc.						PUSH
	2-5" SAME AS 7-13" ABOVE						PUSH
			AQ	2		5	PUSH MOIST
							PUSH OVA HOLE > 1000 PPM
							PUSH
							PUSH WATER TABLE AT 24 FT.
	2-8" MH GRAY BROWN SILT						PUSH SATURATED OVA B.Z. = 0-1 PPM
	(F.F.) SOFT, SMALL ROCK FRAGMENTS, BLACK STAIN		AQ	3		8	PUSH OVA HOLE > 1000 PPM / FORE PLANT
							PUSH OF VAPOR REAGENTS REFER TO CHRON- OLOGY OF SB4)
	2-1" SM-ML BLACK POORLY SORTED SILTY-CLAYEY SAND						3 LIQUID IN SPOON HEAVY BLACK
	1-2" ROCK FRAGMENT IN		AQ	4		2	3 VISCIOUS FLUID WITH TIR-LIKE
	END OF SPOON						4 PIECES
	2-2" ROCK FRAGMENTS WITH BLACK FLUID; 2-8" ML BLACK						5 OVA HOLE > 1000 PPM
	TO DARK BROWN SILTY CLAY WITH ROCK FRAGMENTS; 8-16" SC		AQ	5		16	5 MEDIUM BROWN SILTY CLAY (1/2" L.A.M)
							14 SOME SMALL FINE GRAVEL, SEE 2
							9 FRAGMENTS.
	2-13" ML MEDIUM GRAY, WELL SORTED CLAY-SILT, STEFF, SATURATED, NO OBVIOUS OIL STAINING, NO LAYERING						13 PUT UPPER 2" IN SAMPLE: X111 FOR
			AQ	6		15	8 WORST CASE ANALYSIS
							10 13-15" FRAGMENTED LIMESTONE / FRAGMEN
							12 COLLECT SAMPLE: X112
							9
	0-12" OL MED. TO DARK GRAY SILTY CLAY WITH FOOT FRAGMENTS						9 ROCK FRAGMENT 12-18" ML / GRAY
			AQ	7		20	7 SELT; 18-20" ROCK FRAGMENTS
							19 NO OBVIOUS STAINING;
							17 ADD TO SAMPLE X112

FILL

FILL

FILL(?)

FILL(?)

FILL(?)

LACUSTINE(?)











JOB NO. 06369 HOLE NO. SB1 SHEET NO. 2 OF 2

DEPTH (ft)	DIAMETER (in)	LOG	WELL	WATER	TEMP	REMARKS
0-11	10	10	10	10	10	0-11" ROCK FRAGMENTS LIMESTONE (?) NO OBVIOUS SECTIONS
11	10	10	10	10	10	
12	10	10	10	10	10	
13	10	10	10	10	10	
14	10	10	10	10	10	
15	10	10	10	10	10	
16	10	10	10	10	10	
17	10	10	10	10	10	0-7" ANKLE ROCK (FF 1111) WITH GRAY SALT, NO STAIN- ING
18	10	10	10	10	10	
19	10	10	10	10	10	
20	10	10	10	10	10	
21	10	10	10	10	10	
22	10	10	10	10	10	
23	10	10	10	10	10	
24	10	10	10	10	10	
25	10	10	10	10	10	
26	10	10	10	10	10	
27	10	10	10	10	10	
28	10	10	10	10	10	
29	10	10	10	10	10	
30	10	10	10	10	10	
31	10	10	10	10	10	
32	10	10	10	10	10	
33	10	10	10	10	10	
34	10	10	10	10	10	
35	10	10	10	10	10	
36	10	10	10	10	10	
37	10	10	10	10	10	
38	10	10	10	10	10	
39	10	10	10	10	10	
40	10	10	10	10	10	
41	10	10	10	10	10	
42	10	10	10	10	10	
43	10	10	10	10	10	
44	10	10	10	10	10	
45	10	10	10	10	10	
46	10	10	10	10	10	
47	10	10	10	10	10	
48	10	10	10	10	10	
49	10	10	10	10	10	
50	10	10	10	10	10	
51	10	10	10	10	10	
52	10	10	10	10	10	
53	10	10	10	10	10	
54	10	10	10	10	10	
55	10	10	10	10	10	
56	10	10	10	10	10	
57	10	10	10	10	10	
58	10	10	10	10	10	
59	10	10	10	10	10	
60	10	10	10	10	10	
61	10	10	10	10	10	
62	10	10	10	10	10	
63	10	10	10	10	10	
64	10	10	10	10	10	
65	10	10	10	10	10	
66	10	10	10	10	10	
67	10	10	10	10	10	
68	10	10	10	10	10	
69	10	10	10	10	10	
70	10	10	10	10	10	
71	10	10	10	10	10	
72	10	10	10	10	10	
73	10	10	10	10	10	
74	10	10	10	10	10	
75	10	10	10	10	10	



Field Borehole Log

JOB NO. 06369 HOLE NO. 5B2 SHEET NO. 1 OF 1
 WEATHER FAIRLY WARM INSPECTOR A. G. F. 111
 TEMP. 72 °F STARTED 7:00 A. M. 7/25 1926
 DIP ° FINISHED 10 A. M. 7/25 1926
 ELEVATIONS: DATUM
 CASING DIAM. DRILL PLATFORM
 GROUND SURFACE
 CORE DIAM. WATER LEVELS

LOG LEGEND		# SAMPLE CONDITION		** SAMPLING METHOD		** SHIPPING CONTAINER					
	- SILT		- SAND		- GOOD		- DISTURBED	A - SPLIT TUBE	E - AUGER	N - INSERT	R - CLOTH BAG
	- CLAY		- GRAVEL		- FAIR		- LOST	B - THIN WALL TUBE	F - WASH	O - TUBE	S - PLOUGH BAG
								C - PISTON SAMPLER	K - SLOTTED SAMPLER	P - WATER CONTENT TIN	Y - CORE BOX
								D - CORE BARREL	Q - GLASS JAR	Z - DISCARDED	

LOG	DESCRIPTION: COLOR; CONSISTENCY DENSITY; TEXTURE; STRUCTURE; SHAPE AND SURFACE CONDITION OF GRAINS; ODOR; ETC.	ELEV. = DEPTH	SAMPLE				BLOWS PER 6 INCH	NOTES: BORING; TESTING AND SAMPLING PROCEDURES; WATER LOSS AND GAIN; DRILLING AND TESTING EQUIPMENT; ETC.
			* NO. TYPE	NO.	SIZE (IN.)	RETD (IN.)		
1	0-18" GW BLACK COURSE SAND TO FINE GRAVEL SIZE MATERIAL (CINDERAS (?)) 18"-24" LIGHT GRAY WEATHERED IT MAY BE 17"	1	AQ	5 B 2 1	24	24'	PUSH PUSH PUSH 49	OVA JAR = 500 PPM DAMP DICT. RES. F. (K-1)
2	0-8" ? WHITE FRAGMENTS. 1/2" VERT. SIZE BLACK MATRIX	2	AQ	2	16		41 29 22 35	OVA HOLE > 1000; OVA B.Z. = 0-1 PPM. LEAKED OVA JAR = 300 PPM
3	8-16" ML DARK BROWN MOIST MASSES. SAND WITH BLACK	3	AQ	3	18		40 45 45 17	OVA HOLE >> 1000 PPM; OVA JAR = 100 PPM COLLECT WORST CASE SAMPLE: X109
4	0-18" ML BLACK, VERY STIFF MATERIAL WITH ROCK FRAGMENTS	4	AQ	4	9		7 9 9 7	OVA HOLE >> 1000 PPM; B.Z. = 0-1 PPM FILL(?)
5	MATRIX SILTY/CLAY; LOOKS LIKE OIL STAINED TELL	5	A	5	NO RECOVERY		5 5 7 9	OVA HOLE > 1000; B.Z. = 3 PPM
6	0-9" OL/ML DARK BROWN, MODERATELY SOFT SILTY/CLAY TELL?	6	AQ	6			3 3 3 5	OVA B.Z. = 0 PEAKING AT 4 PPM
7	TOP PORTION LOOKS OIL STAINED BRICK RED, FORE & BACK FRAGMENT	7	AQ	7			3 4 5	REFUSAL AT BOTTOM; LIMESTONE (?) FRAGMENTS IN SOON
8	NO RECOVERY, DRILLER MOUNT HE MAY HAVE BEEN PUSHING PEBBLE	8	AQ	7			5 103	SAMPLE COLLECTED FOR CHEMICAL ANALYSIS: X110



JOB NO. 06369 HOLE NO. SB5 SHEET NO. 1 OF 1

JOB NO. 06369 HOLE NO. SB5 SHEET NO. 1 OF 1

[illegible]